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FLOODS AND CLIMATE CHANGE

Slovenská akadémia pôdohospodárskych vied

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CONTENT

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CHANGE IN THE AMOUNT OF PRECIPITATION IN SLOVAKIA INDUCED BY CLIMATE CHANGE

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Abstract

Today, humanity must cope with the consequences of climate change. Its impacts affect human activity every day. The main areas where the impact of a changing climate is reflected are air temperature, evapotranspiration, and rainfall. These three parts are interlinked. Therefore, when the air temperature increases, the evaporative intensity increases and therefore the volume of water vapor in the atmosphere increases, resulting in higher rainfall.

The aim of this work is to assess the evolution of the average precipitation in Slovakia under a changing climate. The basic input data are taken from 64 meteorological stations in Slovakia and cover the period 1901 - 2020. The whole period under study will be divided into four smaller periods of 30 years to compare them. Esri's ArcGIS Pro will be used to produce map outputs from the input data.

The results show that over the last 120 years the maximum average annual precipitation has increased by 8% and the minimum by 5%. On the other hand, the average value of rainfall has decreased by 2% over this period. Also, the results show that over the last 120 years the average rainfall amounts have not changed significantly. While at the beginning of the study period the

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average values were higher than at present, an increasing trend in these values can be expected in the future. The maximum and minimum rainfall values are also expected to increase.

Keywords: climate change, change of precipitation

1. Introduction

The climate has changed many times in the history of the Earth. It is also known that our planet has experienced periods when global temperatures have risen. When these periods of warming reached their peak, the planet naturally began to cool again. Around a thousand years ago, a warming of the planet occurred, and it has been shown that its onset and progression has not been significantly affected by human activity (Kovár, Zajac, Benediková, 2022).

With the beginning of the industrial revolution in the 18th century, the negative impact of human activities on the climate increased. The transition from manufactures to large-scale industrial production, the use of steam engines and increased air emissions began to change the composition of the atmosphere. The retention of greenhouse gases in the atmosphere is leading to excessive overheating of the Earth's surface. In recent decades, however, this change has been dramatically boosted by increased industrial production and a multifold increase in the planet's population.

The impacts of climate change are mostly negative. They are mainly manifested by increases in annual mean temperatures, increases in annual maximum and minimum temperatures, as well as by the irregularity of precipitation. Weather extremes are also becoming more frequent, accompanied by long periods of drought and sudden extreme rainfall and storms. If a long dry spell is followed by heavy rainfall, the soil is unable to absorb the amount of water in such a short time, so most of the volume runs off as surface runoff. This results in an increased incidence of flooding. Increased surface runoff also promotes an increase in the intensity of water erosion on agricultural land (Djebou, Singh, 2016).

At the beginning of the 20th century, annual rainfall was evenly distributed throughout the year. Due to climate change, this regularity has gradually broken down, resulting in irregular alternation of dry and wet periods throughout the year. This disruption is also reflected in the availability or

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unavailability of water throughout the year. When rainfall has come at regular intervals, groundwater supplies have been replenished at the same time. However, now that rainfall is irregular, of short duration and usually of high intensity, the soil is not able to absorb this volume of water and therefore groundwater recharge is limited (Yawson et al, 2019).

This article is devoted to a comparison of changes in average annual precipitation in Slovakia. The changes were assessed based on meteorological data on average annual precipitation for the period 1901 to 2020. This period was divided into four thirty-year periods.

2. Material and methods

The comparison was made for the period 1901 to 2020. The period of 120 years has been divided into four periods of thirty years each. These periods can be considered as climatic normal. Data on mean annual precipitation for the climatic normal period 1901-1930 were obtained from the publication Proceedings of the Hydrometeorological Institute in Bratislava by Šamaj Ferdinand and Valovič Šimon (1978). Data for the years 1931-1960 were taken from the publication Agroclimatic Conditions of the Czechoslovak Socialist Republic (Kurpelová et al., 1975). For the period 1961-1990 and 1991-2020, data on average precipitation totals were provided by the Slovak Hydrometeorological Institute in Bratislava. The data were provided for 64 meteorological stations evenly distributed over the territory of Slovakia (Figure 1).

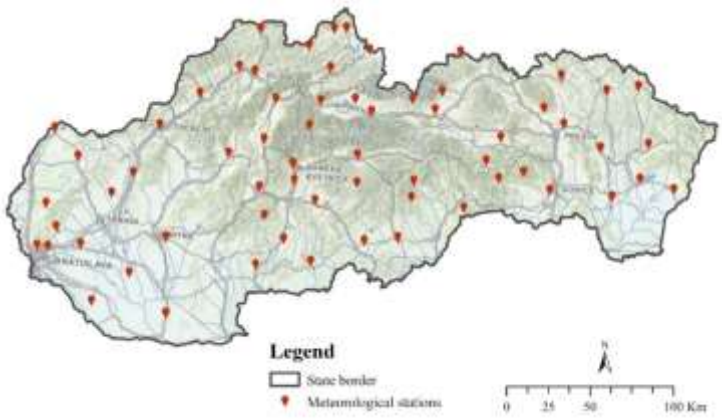

Figure 1 Location of 64 meteorological stations in Slovakia

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The collected data had to be prepared so that it could be used to create map outputs. These were created using Esri's ArcGIS Pro software. This software is suitable for creating analyses where the input data comes from meteorological, climatic, or hydrological measuring stations. Initially, it was necessary to link the input data table to a point layer that contains the location data for each weather station. After linking, we proceeded to interpolation. The latter was necessary to calculate the missing data for the whole territory of Slovakia. For the interpolation, the Topo to Raster function was selected, using which we generated raster layers with a resolution of 100 meters for each period of observation. We classified these rasters into specified intervals of rainfall totals, namely < 550 mm, 550-600 mm, 600-700 mm, 700-800 mm, 800-900 mm, 900-1000 mm, 1000-1200 mm, and 1200-1600 mm. These classifications were determined based on a publication by Kurpelova et al (1975). All the classified layers were then reclassified and transformed into vector layers.

The next step was to remove areas above 800 m asl, as agricultural soils are already represented in a negligible proportion at these elevations. We reclassified the Digital Model of Relief 3.5 (DMR 3.5) with a resolution of 100 m into two classes. The first was up to 800 m a. s. l. and the second was above this altitude. We converted the resulting layer into vector form. Then, using the Clip function, the areas with precipitation above 800 m a. s. l. were removed from the precipitation vector layers.

The thus modified layers were assigned a color scale for each category using Symbology. We also expressed the area of each interval in each 30-year period in an attribute table. The final stage was to generate the map output using the Layout tab. The output was saved in JPEG format, with a resolution of 450 dpi.

3. Results

To assess the changes in the average rainfall amounts for each period, these have been compiled in clear maps. Also, to make them comparable, they have all been classified into the same intervals. The resulting maps can be seen in Figures 2(a) to 2(d).

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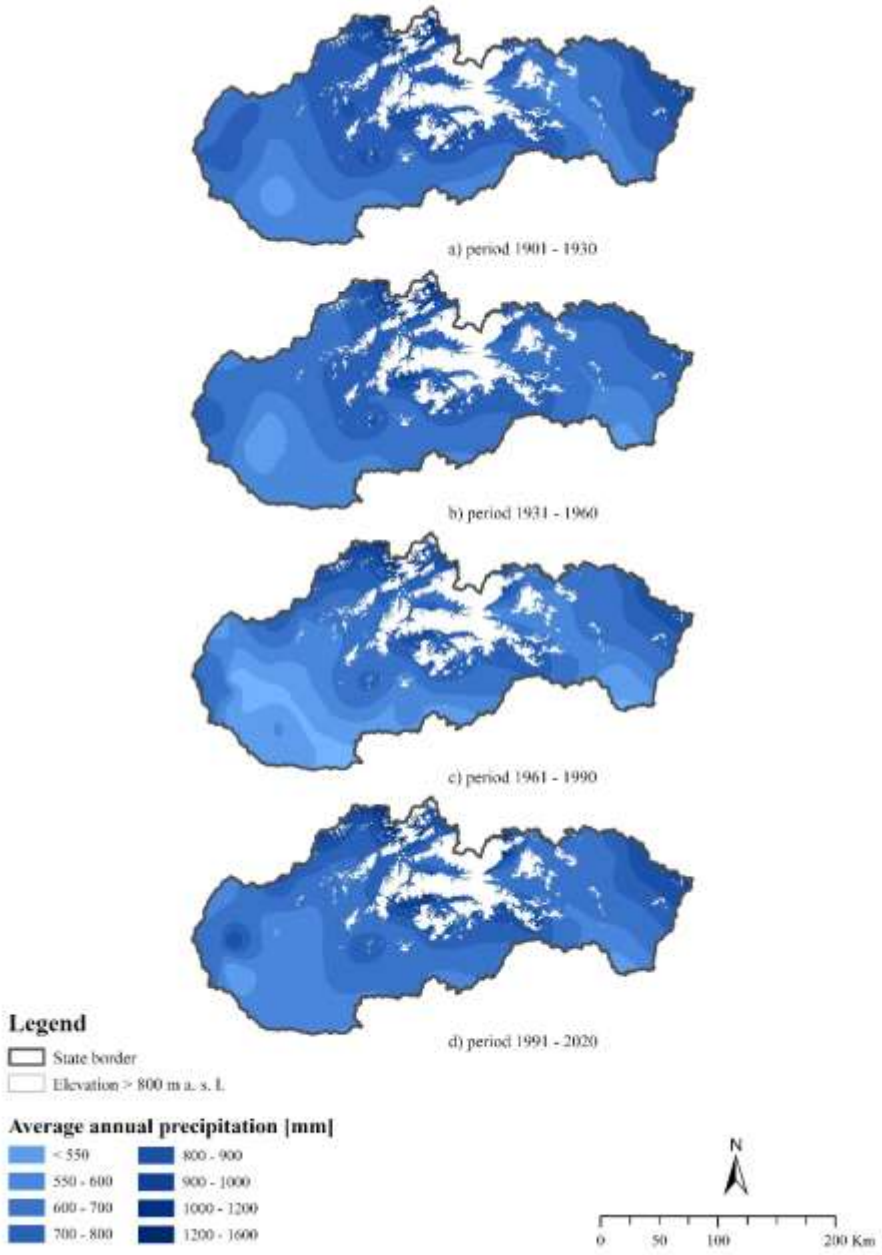

Figure 2 Comparison of changes in precipitation totals for the period 1901 - 2020

For the whole period under study, higher precipitation totals occur at higher elevations in Slovakia. While in the period 1901-1930, the northern parts of Orava, the Western Tatras and the northeastern part of Slovakia experienced the highest rainfall totals in the interval from 1000 to

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1200 mm, at present these parts experience rainfall totals in the interval from 1200 to 1600 mm. Over the years, the zonation of the individual intervals of rainfall heights has shifted from south to north. The Danube and East Slovakian lowlands have been characterized by average rainfall values of 700 mm or less for the entire 120 years.

The period 1961-1990 is a cold period, and our research has also confirmed a decrease in the average value of precipitation compared to other periods. Compared to the years 1901-1930, this decrease was 59 mm on average, which is a decrease of 8 %. Compared to the present, this decrease is 41 mm, or 6 %.

Paradoxically, when we compare the average values of rainfall totals for the period 1901 - 1930 and 1991 - 2020, we observe a decrease in the present rainfall amount compared to the past (Figure 3).

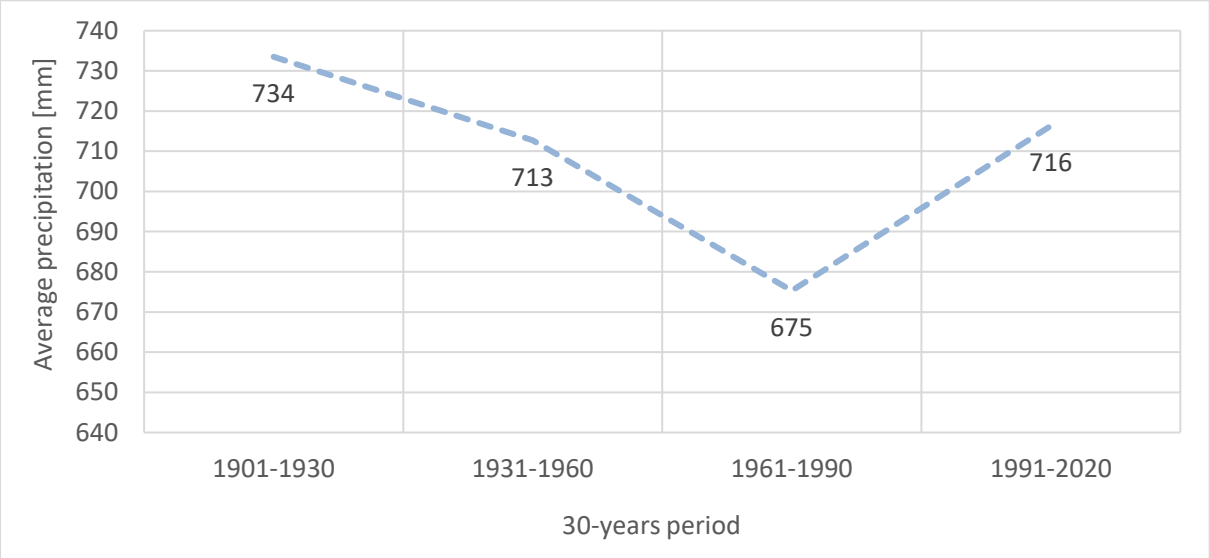

Figure 3 Average precipitation totals

However, an increasing trend can be seen here, so an increase in average values is also expected for the future. On the contrary, the maximum and minimum precipitation totals are higher in the present, whereas they reached lower values in the past (Figure 4).

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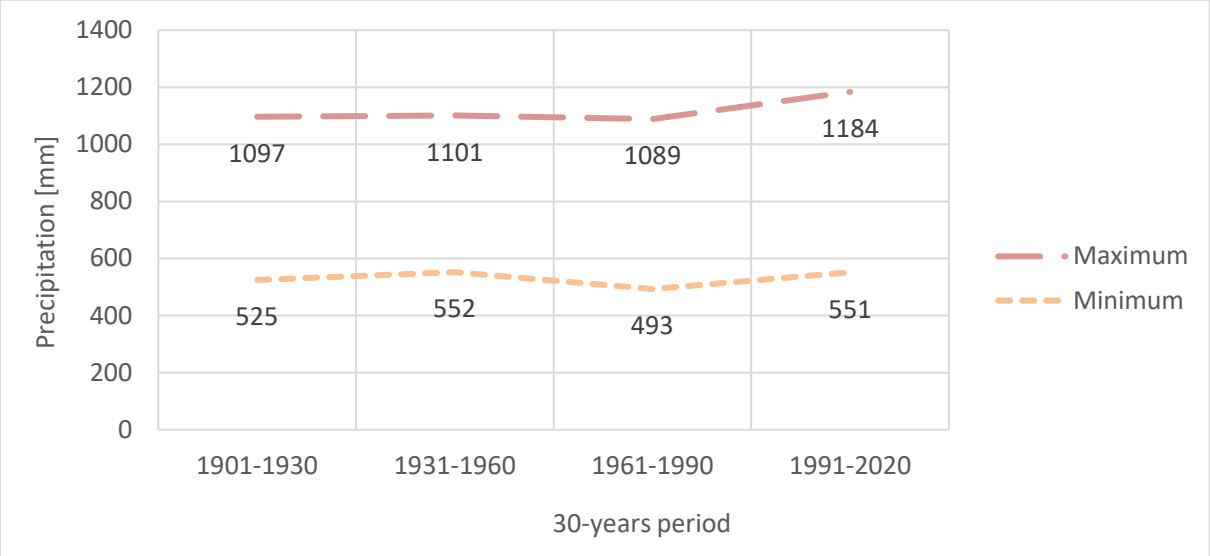

Figure 4 Maximum and minimum mean annual precipitation

4. Discussion

In 2018, Pecho et al. (2018), as part of their research for the Slovak Hydrometeorological Institute in Bratislava, addressed the increasing amount of precipitation in Slovakia. In their research, they used data from precipitation gauge stations in Slovakia for the period 1951-2018. The result of the comparison was that extreme rainfall events with short duration and high intensity have become more frequent in recent decades. Quiet and moderate rainfalls are less frequent. Extreme rainfall often exceeds the capacity of the effective absorption of the soil to hold such large and impactful volumes of water. They further state that since the 1950s, short-term rainfall intensity over Europe has increased by between 4 and 7 %, which is already a high increase. The main cause is increasing global air and surface temperatures, which cause higher evaporation intensities, and increasing water vapor content in the air. A 1 °C warming of the troposphere leads to a 7 % increase in the amount of water vapor in the atmosphere. Even if suitable conditions occur in the atmosphere, an increase in precipitation amounts of 20-50% on average can be expected in some areas compared to the past (Pecho et al., 2018).

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In 2018, Pecho, Markovič and Faško analyzed the maximum 2-day precipitation totals in the territory of Slovakia for the period 1951-2017. They pointed out that due to climate change and increasing air temperature, the water vapor content in the atmosphere has been increasing exponentially over the long term. This fact can be physically justified and is also empirically supported. A change in the atmospheric circulation combined with a long-term increase in air temperature may also be reflected in Slovakia by a change in the distribution of precipitation over the year. In addition, the proportion of storm downpours, total annual and seasonal rainfall may be affected. Furthermore, the intensity of extreme precipitation events increases. Their results show an increase in the frequency of extreme precipitation events, especially in southern Slovakia. They further state that within the cold half of the year, they observed a significant decrease in the 50- and 100-year values of 2-day rainfall totals in some areas. The rest of the area usually showed statistically insignificant increases in these values within the warm half-year (Pecho, Markovič, and Faško, 2018).

As part of the long-term analysis of precipitation totals in Slovakia in 2021, meteorological data from 48 climate stations in Slovakia were analyzed. The data were collected for different periods of time, ranging from 34 to 119 years. During the analysis, the authors focused on the average annual precipitation totals, the occurrence of extreme precipitation totals (> 60 mm / day) and the number of days without precipitation. The results show that the average annual rainfall does not change substantially but is more unevenly distributed over the year than in the past. The number of extreme precipitation events is also increasing, with daily rainfall exceeding 60 mm. In some areas, there has been a decrease in days without precipitation compared to the past (Repel et al., 2021).

The course of precipitation amounts for the years 1981 - 2013 in the territory of Slovakia was analyzed in a study conducted in 2017. The authors considered data on rainfall totals from 487 rain gauge stations in Slovakia. The results show that for the 33 years under study, rainfall totals in the study area have not changed significantly and no large deviations have been recorded. Furthermore, the assumption that the monthly distribution of precipitation is changing was

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confirmed and more changes in this distribution are expected in the future. Most stations show an increasing trend of July precipitation activities, while a decreasing trend of precipitation totals is recorded in the month of December (Zeleňáková et al., 2017).

5. Conclusion

The focus of this paper was to assess the change in the amount of rainfall over the period under review. The period 1901-2020 was selected for comparison. Meteorological data were taken from 64 meteorological stations evenly distributed over the territory of Slovakia. The results show that the average amount of precipitation on the territory of Slovakia has not changed significantly over the last 120 years. When comparing precipitation totals for the period 1901-1930 and 1991-2020, it was found that the average value is currently a few millimeters lower than in the past, but an increasing trend is expected for the future. Also, when comparing the same time periods, an increase in maximum and minimum rainfall values was noted in the present compared to the past. Here too, an increase is projected for the future.

Our findings are also supported by the results of other research aimed at assessing the changes in average precipitation heights in Slovakia. Based on these results, we can assume that more significant differences in the monthly distribution of precipitation are expected in the future. Higher precipitation extremes are also expected.

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EFFECT OF METEOROLOGICAL CONDITIONS AND DIFFERENT CLARIFICATION METHODS OF MUST ON THE POLYPHENOL CONTENT IN WHITE WINES

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Abstract

In our experiment, we compared meteorological conditions during 2 consecutive vintages and the static and dynamic methods of must clarification. We applied white wine varieties 'Riesling Italico' and 'Pinot Grigio' from the vintages 2019 and 2020. In dynamic clarification variants by flotation, we applied air oxygen and oenological additives enzyme, gelatine, and polyvinylpolypyrrolidone. In the static clarification, we used bentonite without the use of antioxidant. In the control variant, we used static clarification method with sulphur dioxide as an antioxidant. The main monitored parameter was the total polyphenol content in the white wine, which we determined spectrophotometrically. The highest content of polyphenols we observed in the control variant of the 'Riesling Italico' variety of the 2019 vintage, namely 379.75 mg/l. In the same vintage, the average total phenolic content in control variant of 'Pinot Grigio' was 245.00 mg/l. In 2020 we measured higher total phenolic content in wine in most of samples. In control variant of 'Riesling Italico' variety we measured total phenolic content 286.00 mg/l and in control variant of 'Pinot Grigio' 249.33 mg/l. Dynamic clarification has no statistically demonstrable effect on the total phenolic content in wine. The hypothesis that different meteorological conditions during vintages influence on total phenolic content was confirmed. In dynamic methods of must clarification with

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the addition of polyvinylpolypyrrolidone at a dose of 10 g/hl would not significantly reduce the total phenolic content in wine.

Keywords: Grape, Wine, Flotation, Meteorological conditions, Phenolic compounds

1. Introduction

Phenolic compounds are a large family of thousands of naturally occurring bioactives that are renowned for their proven health effects (Hornedo-Ortega et al., 2020). Both red and white wine contain complex chemicals called phenolic compounds. They are present in white wines in smaller concentrations than in red wines, but they are nevertheless crucial to the color, antioxidant capacity, and sensory qualities of the wine (Clarke et al., 2022). Phenolics are highly unstable compounds that are essential substrates for oxidation in wine (Pokrývková et al., 2020; Anli & Cavuldak, 2012). Their concentration is particularly high in grape seeds. The content of polyphenols in the fruit of fruit species is varietal specific. Blue grapevine varieties have a higher content of polyphenolic compounds compared to white varieties (Sochorova et al., 2020; Sochor et al., 2014). In comparison to other grape cultivars, several grape cultivars had significantly different phenolic compound profiles (Zhang et al., 2014). The growing conditions of the grapevine and the technology of wine production significantly influence the phenolic content of wine (Singleton, 1988). The reaction of phenolics with oxygen leads to oxidative browning. Oxidation of phenolic substances causes the formation of a variety of volatile compounds significantly affecting the aromatic profile of wine (Catarino et al, 2014). Iron is an essential element for the reaction of oxygen with polyphenols (Danilewicz, 2013). Wines with lower phenolic content are less prone to oxidation. The polyphenols with the highest antioxidant capacity in wine are quercetin and tannin. Resveratrol shows the weakest reducing effects (Pulido et al., 2000). In addition to polyphenols, there are many different compounds in wine that have an oxygenating capacity.

The environment has a big impact on the phenolic compounds in grapes and wines. The terroir conditions were found to be highly well reflected by phenolic substances (Lampíř and Pavloušek,

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2013). Phenolics are significant chemical elements found in wine that serve as indicators of quality and authenticity (Merkyté et al., 2020). White and rosé wines have lower phenolic content and antioxidant capacity than those of red wines (Banc et al., 2020). Develop and change of phenolic compounds throughout time are influenced by factors like pH, aging processes, oxygen levels, and temperature (Seabrook, 2019). Phenolic compounds are recognized to contribute to astringency, oiliness, hotness, viscosity, and bitterness in white wines; however, their effects are determined by the overall structure of the wine (Gawel et al., 2014). The major grape polyphenols include flavan-3-ols, flavonols, proanthocyanidins and anthocyanins from flavonoid family and stilbenes and phenolic acids from non-flavonoid family (Cheynier et al., 2010). Catechins and proanthocyanidins, which are hydroxycinnamic tartaric acid esters, are the main phenolic components in white grape musts (Hornedo-Ortega et al., 2020). Polyphenolic composition in grapes are highly affected by the varietal or genetic differences, environmental conditions and pathogen attacks. One of the most important factors are as well as the viticulture practices and the winemaking process (Hornedo-Ortega et al., 2020; Downey et al., 2006; Pinnasseau et al., 2017). The amounts of phenolics during the winemaking process can also be influenced by certain technological processes, such as the addition of sulphur dioxide (SO_2) and ascorbic acid before crushing the grapes, yeast strain utilization, maceration, alcoholic fermentation, oxidation, or adsorption (Saucier, 2010). Phenolic compounds are connected to astringency and bitterness in flavour (Hornedo-Ortega et al., 2020). These flavour qualities are common in red wines, although bitterness and astringency are not desirable in white wines. Total phenolic content should be on low level in white wines.

2. Material and methods

2.1 Localities

Location I: Nitra wine-growing area, Nitra wine-growing district, Nitra wine-growing region

Location II: Nitra wine-growing area, Radošina wine-growing district, Oponice wine-growing region

 DOI: https://doi.org/10.15414/2023.9788055226217

2.2 Varieties

2.2.1 Riesling Italico (RI)

RI is widely grown variety both in central and eastern Europe. This variety is suitable for producing various wine quality categories. The wines made have a milder scent profile and are light and neutral in character. This grape variety is renowned in our latitudes for its stronger acidity, which it maintains even under warmer temperature cultivation conditions. Grapes of RI variety came from a vineyard in Nitra wine-growing village. The vineyard was eleven years old.

2.2.2 Pinot Grigio (PG)

PG is the result of a budding mutation of Pinot Noir. Western and central Europe are the primary growing regions of PG. In addition to being processed under the higher protected designation of origin category of wines, PG is particularly well suited for the development of attribute wines. Golden yellow in colour, the wine of this varietal has a sweet honey bouquet with tones of orange. It's appropriate for archiving. Grapes of PG variety came from a vineyard in Oponice wine-growing village. The vineyard was twenty years old.

2.3 Grape processing and fermentation

We poured grapes into an electric crusher destemmer, where the grape stems were separated from the must and berries. Maceration of the mash, which lasted 1 hour, took place in a closed tank with a capacity of 350 l. Then we conducted the pressing by hydraulic wine press, using a maximum pressing pressure of 0,1 MPa. After pressing, the total volume of must was homogenised and divided into pre-prepared stainless-steel tanks in which the desilting process took place. According to the variants, we applied oenological additives. We used the same tank for the dynamic clarification and fermentation process. In the case of static clarification, after desilting we pumped a must into prepared stainless steel fermentation tanks. For fermentation, we used

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pure cultures of the wine yeast *Saccharomyces cerevisiae*. The temperature of the fermentation medium was in the range of 18 - 20°C. The fermentation process took 6-11 days depending on the variety and vintage.

2.4 Identification of Variants

Variant I: Use of dynamic clarification (flotation system) and enzymatic substances without the use of sulphur dioxide (RI 1, PG 1).

Variant II: Use of dynamic clarification (flotation system) and polyvinylpolypyrrolidone (PVPP) without the use of sulphur dioxide (RI 2, PG 2).

Variant III: Use of dynamic clarification (flotation system) and flotation gelatine, without the use of sulphur dioxide (RI 3, PG 3).

Variant IV: Use of static clarification and must bentonite without application of sulphur dioxide (RI 4, PG 4).

Control: Use of static clarification and must bentonite with the addition of 25 mg/l sulphur dioxide (RI 5, PG 5).

Harvest 2019: we harvested a grape of the RI variety on October 15 at a sugar content of 20 kg/hL and PG variety we harvested on 23 October at a sugar content of 22.5 kg/hL.

Harvest 2020: we harvested RI grapes on 22 October at a sugar content of 21 kg/hL and PG grapes we on 23 October at a sugar content of 23 kg/hL.

As soon as the grapes were harvested, they were processed, crushed, and pressed. We pumped the pressed and homogenized must into pre-prepared 15-litre tanks. Then, we filled the tanks with the auxiliary oenological excipients designed for clarification.

Variant I: (a) RI 1, (b) PG 1 - Flotation enzyme at a dose of 1,5 g/hl

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Variant II: (a) RI 2 (b) PG 2 - f. Polyvinylpolypyrrolidone at a dose of 10 g/hl

Option III: (a) RI 3 (b) PG 3 - f. Gelatine at a dose of 10 g/hl

Variant IV 4: (a) RI 4 (b) PG 4 - Bentonite at a dose of 50 g/hl

Control: (a) RI 5, (b) PG 5 - Bentonite at a dose of 50 g/hl + 40 mg/l free SO_2

2.5 Method of Total Phenolic Content (TPC) Determination

The modified Folin-Ciocalteu method was used for TPC. Gallic acid was used as the reference material (3,4,5-trihydroxybenzoic acid monohydrate, 99%; Alfa Aesar Thermo Fisher (Kandel) GmbH, Germany), and a stock solution was created by dilution with demineralized water. TPC was converted into a gallic acid equivalent after constructing a calibration curve. (GAE). Wine samples were injected into 50 ml flasks. 2.5 ml of the Folin-Ciocalteu reagent (p.a. purity, Centralchem, Slovakia) were combined with 5 ml of Na_2CO_3 (p.a. 99%; Centralchem, Slovakia); this was diluted with deionized water to a 20% solution (Lachman et al., 2003).

2.6 Description of the Experiment

We established 3 replicates in each variant, in a volume of 10 litres of wine.

2.7 Statistical Analysis

To the statistical analysis, we used the Tukey test (least significant difference test, $P \leq 0.05$).

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3 Results and discussion

3.1 Weather conditions

Table 1 Temperature and precipitation in 2019 and 2020 in Nitra, Slovakia

	Year 2019				Year 2020			
Month	t [°C]	Dt [°C] (normal 51-00)	Precipitation [mm]	% of normal (51-00)	t [°C]	Dt [°C] (normal 51-00)	Precipitation [mm]	% of normal (51-00)
I.	-2.3	-0.9	49.7	171	-0.2	1.2	8	26
II.	3.2	2.7	21.8	72	5.2	4.7	36	119
III.	8.1	3.3	15.6	49	6.6	1.8	64	202
IV.	9.4	-1.0	21.4	51	11.3	0.9	5	13
V.	9.3	-5.9	134.8	241	13.8	-1.4	39	69
VI.	18.7	0.4	29.0	44	19.2	0.9	81	123
VII.	21.9	1.9	21.0	35	20.8	0.8	22	37
VIII.	22.3	2.6	83.7	154	22.1	2.4	73	135
IX.	16.2	0.7	60.3	140	16.9	1.4	92	214
X.	12.0	1.8	15.0	37	11.0	0.8	140	341
XI.	8.4	3.8	88.8	170	4.8	0.2	14	26
XII.	3.3	2.8	45.1	104	3.4	2.9	41	95
Year	10.9	1.0	586.2	107	11.2	1.3	614	112

(SHMÚ, 2021) Note: t - average month temperature, Dt – temperature deviation from normal

Weather conditions in year 2019 and 2020 we presented in Table 1. The average annual temperature in 2020 was 0.3 °C higher than in 2019. The average annual precipitation in 2020 was 27.8 mm higher than in 2019.

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The warmest month in 2019 was August with average monthly temperature 22.3 °C. The coldest month in vegetation season 2019 (April - October) was May with the monthly temperature 9.3 °C and anomaly -5.9 °C in comparison to normal (1951 - 2000). The highest monthly precipitation was in May. The lowest precipitation was in October, during the grape ripening.

The warmest month in 2020 was August. Average temperature in this month was 22.1 °C. The coldest month in vegetation season 2020 was October with average monthly temperature 11.0 °C. The highest monthly precipitation was in October. The lowest precipitation was in April.

3.2 Total phenolic content - Riesling Italico

In Table 2 we present total phenolic content of the RI wine. In 2019, we did not observe any statistically significant differences between the total phenolic contents in the variants of the dynamic clarification procedure for RI wine. In the control variant utilizing sulphur dioxide, we discovered the highest concentration of phenolic compounds. There is a statistically significant difference between the control variation and the other studied variants.

In 2020, we found that the variant with the enzyme addition had the greatest phenolic concentration among the dynamic clarification variants of RI wine. The static clarification variant with bentonite addition had the highest concentration of phenolic compounds of all the studied variants. There is no statistical evidence to prove the difference between the variation using PVPP and gelatine. There is statistical evidence to support the differences between the other studied variants.

Rihak et al. (2022) claims that oenological additives can lead to lower content of phenols in wine in the contrast to the control variant. In 2019 measurements, we detected lower content of total phenolic content in variants using oenological additives.

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Table 2 Total phenolic content [mg GAE/l] – Riesling Italico

Variant	Average	sd	min	max	cv
19 RI 1	239.25b	8.86	232.25	251.75	4.54
19 RI 2	245.25b	9.88	236.25	259.00	4.93
19 RI 3	247.17b	4.25	241.5	251.75	2.11
19 RI 4	260.58b	1.66	258.25	262.00	0.78
19 RI 5	379.75a	5.93	372.25	386.75	1.91
20 RI 1	302.58b	2.12	300.50	305.50	0.86
20 RI 2	254.83d	3.17	250.50	258.00	1.52
20 RI 3	251.33d	5.32	245.75	258.50	2.59
20 RI 4	327.42a	5.11	321.00	333.50	1.91
20 RI 5	286.00c	6.62	279.25	295.00	2.84

Note: 19 – year 2019, 20 – year 2020, RI – Riesling Italico, SD – standard deviation, Min – minimum, Max – maximum, CV – coefficient of variation, GAE/l - gallic acid equivalent per liter; a, b, c, d means rows with different letter are statistically different (Tukey test, $p < 0.05$).

In 2020, all examined variants of RI wines had higher total phenolic content excepting variant of static clarification using SO_2. Our results confirm the influence of vintage on total phenolic content in RI wine. This finding is consistent with the results of Lee et al. (2009). They prove a vintage influence on selected phenolic compounds in two consecutive vintages. Authors found a reason of

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higher phenolic content in lower precipitation and more sun-exposed time. In 2020, we found higher precipitation and higher total phenolic content in wines. Our findings differ from the results of Lee et al. (2009).

3.3 Total phenolic content - Pinot Grigio

Table 3 Total phenolic content [mg GAE/l] – Pinot Grigio

Variant	Average	sd	min	max	cv
19 PG 1	197.17b	5.44	192.25	204.75	3.38
19 PG 2	196.58b	1.76	194.25	198.50	1.10
19 PG 3	194.33b	6.68	189.00	203.75	4.21
19 PG 4	245.58a	8.15	238.50	257.00	4.06
19 PG 5	245.00a	6.75	239.50	254.50	3.37
20 PG 1	257.25c	6.60	251.50	266.50	3.14
20 PG 2	296.00a	3.09	293.00	300.25	1.28
20 PG 3	273.83b	2.97	271.25	278.00	1.33
20 PG 4	238.42d	1.12	237.00	239.75	0.58
20 PG 5	249.33cd	2.57	246.00	252.25	1.26

Note: 19 – year 2019, 20 – year 2020, PG – Pinot Grigio, SD – standard deviation, Min – minimum, Max – maximum, CV – coefficient of variation, GAE/l - gallic acid equivalent per litre; a, b, c, d means rows with different letter are statistically different (Tukey test, $p < 0.05$).

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In Table 3 we show total phenolic content of the PG wine. In 2019 variants of the dynamic clarification, we did not discover any statistically significant differences in the phenolic content of the samples. In comparison to the dynamic clarification variants, the static clarification variants included statistically significantly higher total phenolic content.

In 2020, we discovered that the variant with PVPP addition had the greatest phenolic content among the dynamic clarifying variants of PG wine. There is no statistically significant difference between the version with enzyme application and the control variant. There is no statistically significant difference between the static clarification variants. There are statistically significant differences between the dynamic clarification variants.

In 2020, all examined variants of PG wines had higher total phenolic content excepting variant of static clarification method using bentonite. Our results confirm the influence of vintage on total phenolic content in PG wine. Rouxinol et al. (2023) studied the climatic effect on polyphenolic composition of red wine grapes. Their study demonstrates differences in polyphenol compounds between vintages. Higher phenolic content they connect with lower precipitation and higher temperatures. However, in 2020 we detected higher precipitation along with higher total phenolic content in wines. The statement of Rouxinol et al. (2023) conflicts with our results.

If we compare RI and PG varieties, in our samples we found statistically significant differences in TPC. In 2019, we measured higher TPC in all samples of RI variety in comparison to PG variety.

Ailer et al. (2021) reported a technique for targeted oxygenation of must or mash to reduce polyphenols in white wines without affecting sensory alterations. According to the authors, the yeast uses the extra oxygen left over from must hyperoxidation to produce the necessary esters and higher fatty acids. We can get rid of extra phenolic compounds from mash or must without utilizing sulphur dioxide or any other antioxidants by letting it oxidize for a while in the presence of outside oxygen. Accordingly, antioxidants are not used in the grape processing method until the

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must has been cleaned. Phenolic compounds in must or mash are oxidized by the atmospheric oxygen and sedimented during the clarification procedure (Pokrývková et al, 2020).

Coelho et al. (2018) discovered that the must clarification technique does not result in a statistically significant change in TPC. TPC is more significantly impacted by vintage than by must clarification.

4 Conclusion

We are unable to definitively suggest the optimal technique for dynamic clarification considering the findings. The values of the total phenolic content in the two types under study were affected differently by each clarification method. The TPC content of wine is not statistically affected by dynamic clarifying. It was not proven that PVPP lowers the amount of TPC in wine. In the vinification of white wines, flotation is crucial, especially when grapes are harvested mechanically and are severely damaged. It is crucial to choose the right oenological processing tool, use high-quality technical equipment, observe action times, and practice good hygiene. The assumption that different climatic factors during vintages affect total phenolic content in wine were proven.

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ADSORPTION OF COPPER FROM NEUTRAL MINE EFFLUENTS USING NATURAL BENTONITE AND STABILIZED DEWATERED DIGESTED SLUDGE

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Abstract

One of the main factors of the pollution of aquatic ecosystems by industrial activities is the increase in heavy metal concentrations. The aim of this study was to investigate the adsorption efficiency of Cu using stabilized dewatered digested sludge and bentonite. The sorption was evaluated using Freundlich and Langmuir adsorption isotherms, isotherm parameters, the dependence of the amount of adsorbed Cu on the initial concentration, Cu adsorption as a function of time, and Pseudo first and second order rate constants. The suitability, unsuitability of using Freundlich or Langmuir adsorption isotherms was not clearly confirmed by experimental measurements. The maximum monolayer adsorption capacity qm for Cu adsorption using bentonite sorbent was determined to be 1.7 $mg.g^{-1}$. The highest percentage of Cu removal efficiency was observed using bentonite sorbent and sludge of about 60 %. The sludge was confirmed as a comparable sorbent in the sorption of Cu compared to the other two sorbents used. The main novelty of the work lies in the sorption using dewatered digested sludge. Previous studies have focused on metal sorption using activated sludge. This type of sludge is interesting as it is a waste stream of waste. Another novelty of our scientific paper is the comparison of the sorption of this waste sorbent with natural

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sorbents, which, based on the studies mentioned in the introduction, are widely used for the sorption of metals.

Keywords: adsorption, copper, neutral mine drainage, natural sorbent, dewatered digested sludge

1. Introduction

Industrial processes generate a huge amount of wastewater that needs to be treated before being discharged into the environment (Saadi et al., 2015). Heavy metal pollution has emerged as one of the most serious current environmental challenges. The removal of heavy metals from wastewater is of environmental importance due to their toxicity. Unlike organic pollutants, heavy metals are not biodegradable and are persistent in the environment (Tutu, 2017). Examples of heavy metals include lead, copper, zinc, nickel, cadmium, and chromium (Cherono et al., 2021). Copper is necessary for enzyme synthesis, bone, and tissue growth. However, at high concentrations, copper is toxic (Akar et al., 2009; Ding et al., 2014).

Mine drainages are rich in heavy metals and sulphur, which are present in minerals (Gray, 1997; Pereira et al., 2014). Heavy metals present in mine effluents often include copper (Dold, 2014). Copper can precipitate as CuS at extremely low pH (pH ≤ 1.0) without precipitating other heavy metals (Sahinkaya et al., 2009). In many cases, due to the neutralizing ability of waste minerals or human intervention such as the spreading of limestone to precipitate metals, the drainage may have higher pH values (4.5 to 8.5) and is then called neutral mine drainage (NMD) (Banks et al., 1997). This can cause serious environmental problems in mining environments because heavy metals, which are often present in high concentrations, can remain soluble at alkaline pH under suitable redox conditions (Lindsay et al., 2009; Pereira et al., 2014).

Currently, the main methods for the treatment of wastewater containing heavy metal ions include the ferrite method, chemical precipitation, electrochemical method, reverse osmosis, ion exchange and adsorption (Wang et al., 2022). At present, the development of new adsorbents favours locally available and inexpensive natural materials, which are combined with each other

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to obtain the desired adsorption properties (Crini and Morcellet, 2002). Several cost-effective, natural, and renewable materials was confirmed as adsorbents e.g., chitosan, tea leaves, brown coal, waste sludge, agricultural waste, biomass (Ahmaruzzaman, 2008; Kalderis et al., 2008; Munagapati et al., 2010). Organic waste materials can be used to remove metals from mine effluents by adsorption and precipitation, which serves as an effective low-cost substitute for activated carbon (Hughes et al., 2013).

The adsorption isotherms provide information about the adsorption process. The analytical forms of the adsorption isotherm equations depend on the type of surface phase, which can be considered as monolayer or multilayer and as localized, mobile. These models are complicated because of the structural and energetic heterogeneity of adsorbent surfaces, which is characteristic of many adsorbents used on an industrial or experimental scale (Jaroniec and Madey, 1989).

In this work, we investigated the removal of Cu using stabilized digested dewatered sludge (SDDS) and bentonite.

2. Material and methods

2.1. Characterisation of sorbents

2.1.1. Stabilized digested dewatered sludge

SDDS was used in the study. Stabilized sludge was used specifically to remove pathogenic microorganisms that could cause hygienic complications when this sorbent is applied to the aquatic ecosystem. The sludge was dried and sieved to a fraction below 2 mm.

2.1.2. Bentonite

Ground fine bentonite was used for better contact between the sorbent and the sample. Bentonite was obtained from the Kopernica site. The sludge was dried and sieved to a fraction below 2 mm.

 DOI: https://doi.org/10.15414/2023.9788055226217

Table 1 Mineral composition of bentonite (%) (Deliova et al., 2015)

Smectite	Quartz	Illite	Feldspar	Biotite	Kaolinite	Cristobalite
80	6	-	8	2.5	2	1.5

Table 2 Chemical composition of bentonite (%) (Deliova et al., 2015)

SiO_2	Al_2O_3	CaO	Fe_2O_3	MgO	MnO	Na_2O	K_2O	TiO_2	P_2O_5	SO_3
66.09	23.96	1.90	2.69	2.93	0.05	0.43	1.68	0.15	0.01	0.11

2.2. Characterisation of neutral mine drainage

Neutral mine drainage was taken from the Voznická dedičná štôlňa adit (Central Slovakia). The average pH over 2 years in neutral mine drainage was 7.24. Aqueous solutions were used for sorption. The concentration of copper in them was modified with selected copper salts for the needs of 5 input concentrations.

2.3. Sorption of heavy metals

Adsorption experiments were carried out in closed Erlenmeyer flasks at laboratory temperature by mixing the sorbent with 100 cm^3 of neutral mine drainage solution. Sorbent concentrations of 5 $g.dm^{-3}$ were used in the experiment. The samples were periodically mixed at a constant speed (200 rpm) using an electromagnetic stirrer. Sorption was carried out at laboratory temperature 20 °C. The sorption experiment was carried out in parallel samples. The first represented the input concentration. At minute intervals, sorption was gradually interrupted in individual samples. After stopping the sorption in a 100 ml sample, the solution was filtered, and the concentration of copper was determined in it. This experiment was repeated 6 times for the same input concentrations and the sorption results were averaged. 5 different inlet concentrations were achieved by adding copper salt to neutral mine drainage. In four of the five samples, the sorbent

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concentration was the same 5 g. dm^{-3}. The only sample where no sorbent was added was the sample for determining the input concentration. The range of input - zero concentration of copper was chosen depending on the measuring range of the instrument used for the determination of metals.

2.4. Determination of heavy metal concentrations

The concentrations of metals were determined by atomic absorption spectrometry (AAS). An AAS AVANTA Σ flame atomization spectrometer (GBC Scientific, Australia) was used for the determination of metals. A hollow cathode lamp with a supply current of 3.00 mA was used as the radiation source. Air/acetylene was used as the flame type at flow rates of 11.50 $dm^3.min^{-1}$ for air and 1.10 $dm^3.min^{-1}$ for acetylene. The relative errors of the AAS measurements were less than 5%. The instrument operation as well as the evaluation of the results was carried out with the GBC Avanta software ver. 2.0.

2.5. Calculations

2.5.1. Adsorption capacity

From the measured concentrations, the adsorption capacity at equilibrium (q_e), the amount of metal adsorbed per unit sorbent at time t (qt) and the percentage removal efficiency of Cu^{2+} ions from the solution (Ads. %) were calculated.

The adsorption capacity at equilibrium and at time t, respectively, was calculated according to Eqn.:

$$q_e = \frac{(c_o - c_e)\cdot V}{m} \qquad \text{Eqn. (1)}$$

 DOI: https://doi.org/10.15414/2023.9788055226217

where c_0 is the initial concentration of ions in solution (mg.dm^{-3}), c_e is the equilibrium concentration of ions in solution or the concentration of ions in solution at time t (mg.dm^{-3}), V is the volume of solution (dm^{-3}) and m is the mass of adsorbent added (g).

2.5.2. Percentage of metal ion removal efficiency

The percentage removal efficiency of metal ions from the solution was calculated according to Eqn.:

$$\text{Ads.\%} = \frac{(c_0 - c_e)}{c_o} * 100\ [\%] \qquad \text{Eqn. (2)}$$

Experiments focused on the adsorption of copper was carried out with natural unmodified adsorbents in a closed system under constant stirring of the suspension at laboratory temperature. We monitored the progress of sorption depending on the sorbent.

2.5.3. Freundlich and Langmuir adsorption isotherms

To express the dependence of the adsorbed amount of a metal ion on its equilibrium concentration in solution, Freundlich and Langmuir isotherms were constructed for all adsorbents used. The isotherms were evaluated at 5 input concentrations.

The effect of initial metal concentration on adsorption is described by adsorption isotherms. Several empirical and semiempirical relationships have been proposed for the analytical expression of the isotherms, of which either the Freundlich or Langmuir isotherm is the most suitable for adsorption from solutions.

The Freundlich isotherm is usually valid for physical adsorption and for adsorption on heterogeneous surfaces with different active sites. It can be expressed by the relation:

$$q_e = K_f \cdot c_e^{\frac{1}{n}} \qquad \text{Eqn. (3)}$$

 DOI: https://doi.org/10.15414/2023.9788055226217

To verify that the experimental data satisfies this isotherm, the relationship is linearized:

$$\log q_e = \log K_f + \frac{1}{n}\log c_e \qquad \text{Eqn. (4)}$$

where K_f (mg.g^{-1}) is a constant related to the adsorption capacity and n is an empirical parameter expressing the adsorption intensity, which varies with adsorbent heterogeneity.

The Langmuir isotherm is usually valid for chemisorption or electrostatic adsorption, where only a monomolecular layer is formed on the adsorbent surface and all active centres are equivalent. The Langmuir isotherm is expressed by the relation:

$$q_e = \frac{q_m \cdot b \cdot c_e}{1 + b \cdot c_e} \qquad \text{Eqn. (5)}$$

respectively in linearized form:

$$\frac{c_e}{q_e} = \frac{1}{b \cdot q_m} + \frac{1}{q_m} \cdot c_e \qquad \text{Eqn. (6)}$$

where q_m (mg.g^{-1}) gives the maximum monolayer adsorption capacity and b is the equilibrium constant dependent on the sorption energy.

3. Results and discussion

3.1. Parameters of adsorption isotherms

The suitability, unsuitability of using the Freundlich or Langmuir adsorption isotherm was not clearly confirmed by experimental measurement (Table 3). Therefore, it is necessary not to focus on one type of isotherm in the evaluation, but to first determine the optimal isotherm by experimental comparison.

Based on the constructed Freundlich adsorption isotherm, the maximum monolayer adsorption capacity q_m for Cu sorption using bentonite sorbent was determined to be 1.7 mg.g^{-1}. The lowest

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value of q_m for Cu sorption was observed using stabilized dewatered sludge. On the contrary, the lowest q_m value was again observed using stabilized dewatered sludge. The sorption intensity parameters for Cu adsorption were at similar levels.

Table 3 Parameters of Freundlich and Langmuir adsorption isotherms for Cu sorption using bentonite and digested dewatered sludge.

Parameters of Freundlich and Langmuir adsorption isotherms						
Adsorbent	**Langmuir parameters**			**Freundlich parameters**		
	q_m (mg.g^{-1})	**b (dm^3.mg^{-1})**	**R^2**	**k_f (mg.g^{-1})**	**n**	**R^2**
Bentonite	1.374	0.379	0.8006	0.380	1.951	0.942
Digested dewatered sludge	-7.2675	0.041	0.3841	0.2846	1.1052	0.9831

3.2. Effect of initial concentration

For Cu sorption, the highest sorption was observed for bentonite and sludge at initial concentration 1,33 mg.dm^{-3} – 77,5 % and 61 % (Fig. 1). With increasing initial concentration of Cu in solution the removal efficiency slightly decreased. However, initial concentration did not have a significant impact on removal efficiency of sludge as it fluctuated between 50-60 %.

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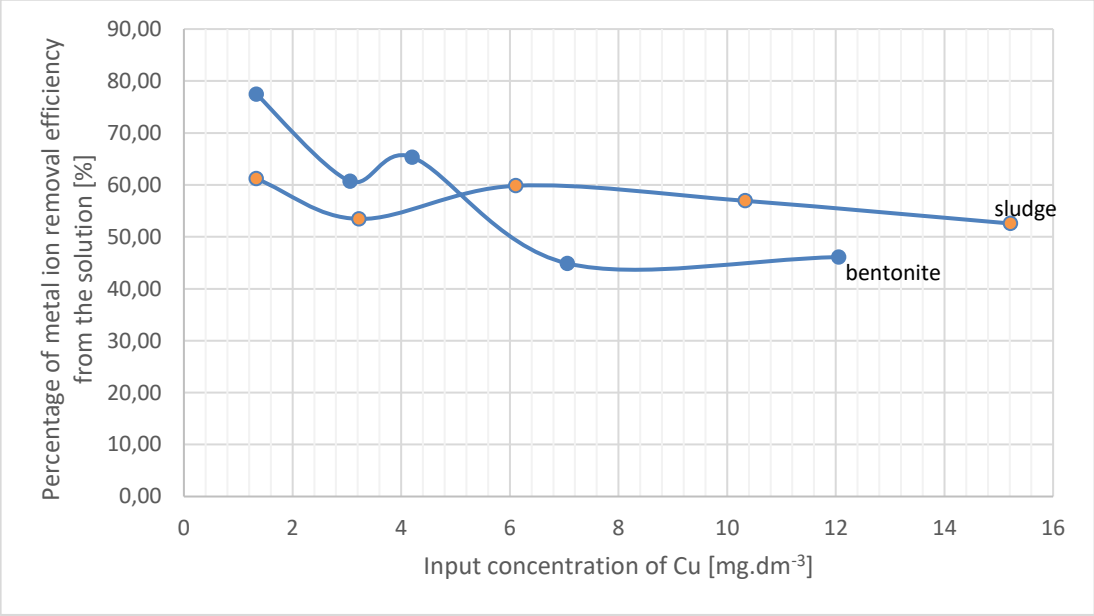

Figure 1 Correlation between the amount of copper absorbed and it's the initial concentration using different sorbents

According to Kobilay et al. (Kubilay et al., 2007) the adsorption capacity of bentonite increased linearly with metal ion concentration. At metal ion concentrations >50 mg/l, there were no further changes in adsorption. These results suggest that the pores of clay minerals filled up over time and the increased metal ion content had no significant effect on adsorption. Maximum adsorption was obtained at 20 °C and pH 7.0 – 95.60 % Cu^{2+}.

Chang et al. observed that the amount of adsorbed copper and nickel per unit weight of adsorbents increased gradually with increasing initial metal ion concentration, with the higher the initial concentration, the lower the removal percentages. At low ion concentrations, the ratio of the number of available adsorption sites to the number of metal ions was large, and therefore a high proportion of metal ions were removed from the bulk solution. Consequently, at low initial concentration, the adsorption depends on the initial metal concentration (Chang et al., 2020).

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Melicova and Hromada confirmed that with increased concentration of Cu^{2+} ions, the adsorption capacity of bentonite increased from 6.70 to 10.74 $mg.g^{-1}$ and the percentage of removal decreased from 74.28 % to 21.81 % (Melichová and Hromada, 2013).

3.3. Effect of contact time

The sorption rates varied significantly depending on the input metal concentration. For Cu sorption using bentonite, the highest sorption of Cu was observed at 30 – 90 minutes of sorption at an input concentration of 8.4 $mg.dm^{-3}$ (Fig. 2). By sludge sorption at an input concentration of 2.4 $mg.dm^{-3}$, the most rapid sorption was observed at a time of 60 – 120 min (Fig. 3).

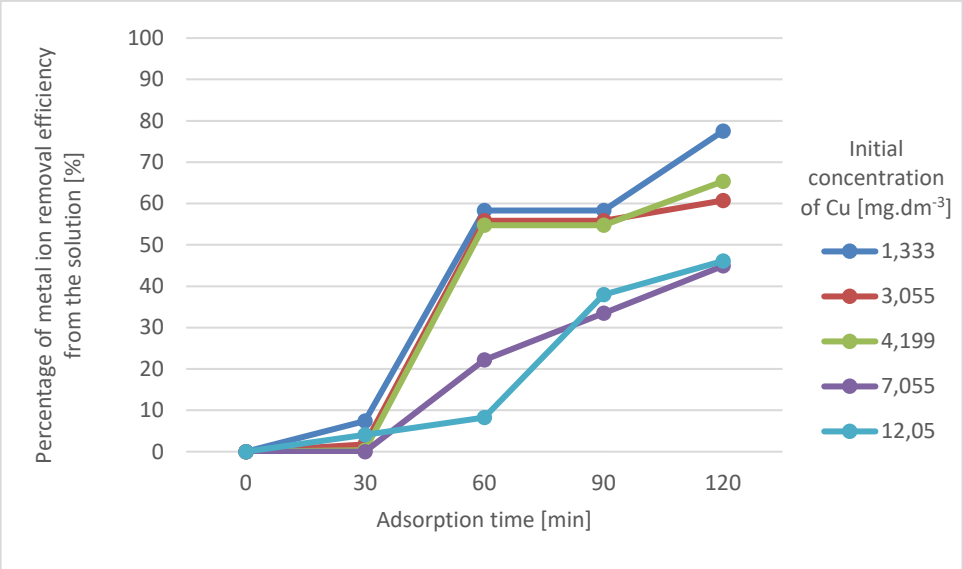

Figure 2 Sorption of Cu using bentonite

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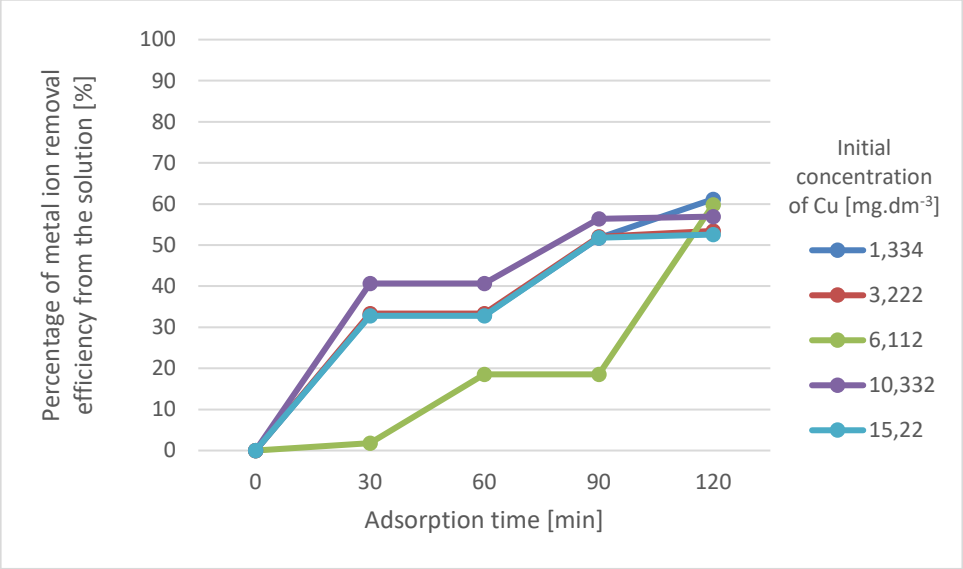

Figure 3 Sorption of Cu using sludge

Chang et al. found that the adsorption of copper and nickel onto bentonite was rapid for the first 15 min, then increased significantly and reached equilibrium in 90 min, with approximately 71% of copper and 62% of nickel sorbed during this period (Chang et al., 2020).

Bourliva et al. confirmed that the rate of adsorption was very fast during the first 20 min of adsorption and during this period 82.6% (40.1 $mg.g^{-1}$) Pb^{2+}, 59.2 % (20.2 $mg.g^{-1}$) Cd^{2+}, 52.3 % (18.4 $mg.g^{-1}$) Cu^{2+} and 35.1 % (16.59 $mg.g^{-1}$) Ni^{2+} were adsorbed. Further prolongation of the contact time did not result in a subsequent increase in adsorbed metal ions. However, a contact time of 120 min was used to ensure maximum metal removal in all experiments conducted (Anna et al., 2015). This finding is in agreement with previous studies in which rapid adsorption of metal ions (10 – 20 min) has been reported (Betsiou, 2010; Vieira et al., 2010). During the initial phase of sorption, many free surface sites are available for adsorption. After some time, the remaining vacancies on the surface become difficult to occupy due to the repulsive forces between the solute molecules adsorbed on the solid surface and the bulk phase (Srivastava et al., 2008). The results indicated that the adsorption of Cd^{2+}, Cu^{2+}, Ni^{2+} and Pb^{2+} on bentonite was mainly attributed to chemical sorption rather than physical sorption (Yang et al., 2010).

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Bellir et al. confirmed that chemical equilibrium is reached rapidly. In fact, there are two distinct phases, the first is very short and adsorption is rapid due to the sorption of metal ions onto the sorbent surface, and the second is relatively slower over time and reaches a plateau after about 60 min. This phenomenon could perhaps be attributed to the immediate utilization of the most readily available adsorption sites on the adsorbent surface. Equilibrium was reached within 180 min (Bellir et al., 2013).

These results show that bentonite can be effectively used to remove Cu^{2+} based on ion-exchange mechanism from aqueous solution and wastewater. This naturally occurring clay mineral can provide a substitute for the use of expensive adsorption materials such as activated carbon, due to its availability and its relatively low cost. It has been shown in many studies that activated carbon is an effective adsorbent for organic compounds, specifically phenolic compounds. However, it's the need for an expensive regeneration system makes it less economically viable as an adsorbent. Cost efficiency, availability, and adsorption properties are the main criteria for selecting an adsorbent for the removal of inorganic and organic compounds. Taking these criteria into account, it can be said that naturally available bentonite will be able to be used as a more economical adsorbent for adsorption of metal cations without requiring expensive regeneration instead of activated carbon, which is a conventional adsorbent (Kubilay et al., 2007).

The rapid reaction during the initial phase of adsorption was the result of the immediate exchange of copper and nickel ions with cations at the outer planar sites and peripheral sites of the bentonite platelets, which accounted for approximately 4 % of the total surface area of the bentonite particles. This rapid reaction was followed by slow diffusion of cations into the expandable interlayer spaces of the smectite structures, which formed >90 % of the exchange sites (Chang et al., 2020).

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4. Conclusions

The suitability, unsuitability of using Freundlich or Langmuir adsorption isotherm has not been clearly confirmed by experimental measurements. The maximum monolayer adsorption capacity q_m for Cu sorption using bentonite sorbent was determined to be 1.7 $mg.g^{-1}$. For Cu sorption, the highest sorption was observed when bentonite and sludge were used - approximately 60 %. The sorption rates varied significantly depending on the input metal concentration.

Acknowledgment

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DENDROMETRIC MEASUREMENTS OF *ZEA MAYS* UNDER WATER STRESS CONDITIONS

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Abstract

Drought is defined as a recurrent extreme climatic phenomenon affecting land and lasting for several months or years due to below-average rainfall and often high temperatures. Water deficit or water stress occurs when the amount of water falls below its optimum and consequently disrupts normal plant processes (growth, stomatal conductance, rate of photosynthesis). Water stress is problematic for plant growth and development because it reduces the internal transport of water, blocking the stomata, thereby limiting access to photosynthetic reserves. As a result, water stress impairs the plant's ability to function properly and causes morphological, physiological and biochemical changes in an attempt to compensate for water deficit.

The aim of the research was to determine the stress factors so that in the future, depending on monitoring data, it will be possible to respond by compensating for them. *Zea mays* was used as a crop in the study. Plants were grown in a room with a temperature of 20 to 25 °C and humidity of 55 to 60% with MARS HYDRO artificial LED lighting set to 12 hours of light. Radial changes on the plant stems were monitored by a DD-S type dendrometric sensor to measure radial changes. The collected data were then stored in a dendrometric data logger DL 18. Continuous data collection was carried out at hourly intervals from 15.4.2023 to 4.5.2023. Nine plants were divided

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into three groups of three plants each. All plants were irrigated at one-day intervals. Group 1 received 5 ml irrigation per plant, group 2 received 2 ml irrigation per plant, while group 3 received no irrigation. In the first group, we observed a stagnation of stem diameter to a slight decrese of 0,27 %. The second group showed decrease of 2,44 %. In the third group we observed decrease of 4,34 % in stem diameter. Considering the above results, we can observe a visible water stress in the plants under experimental conditions. In the future, it will be necessary to monitor changes throughout the growing season so that we can adjust the irrigation rate for the needs of the plants at specific developmental stages.

Keywords: water stress, dendrometers, *Zea mays*

1. Introduction

Zea mays, also known as maize or corn, is a prominent crop species due to its historical, economic, and scientific importance. As one of the world's most frequently cultivated crops, it has played an important part in human civilization, providing nutrition, economic possibilities, and stimulating scientific research. Its domestication in the Americas by ancient civilizations changed it from a wild grass to a highly productive crop (Tandzi and Mutengwa, 2020). Maize has a wide global range, with cultivation in a variety of climates and countries. *Zea mays* has evolved to a remarkable range of climatic circumstances, from huge cornfields in North America to terraced slopes in the Andes and subsistence farms in Africa and Asia. This versatility has contributed to its popularity as a staple food source, enabling food security for millions of people throughout the world (Cabral et al., 2017). Corn has made major contributions to a variety of businesses aside from its role as a staple crop. Its kernels are used to make a variety of culinary items, animal feed, and industrial components such as ethanol and bioplastics. The stalks and wastes are used to make biofuel, animal bedding, and as a source of biomass for electricity generation. Furthermore, *Zea mays* is a useful model organism for scientific research, providing insights into plant development, genetics, and biochemistry (Strable and Scanlon, 2009).

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Drought, heat, and flooding are becoming more common as a result of increased urbanization and habitat destruction, as well as other unforeseen extreme climatic occurrences, putting a strain on a variety of critical crops. The warming global climate also poses a long-term challenge to maize crop development. Climate change models predict that agricultural output would plummet, restricting many regions' ability to achieve the technical breakthroughs required for future food security. Drought is one of the most damaging abiotic stresses in agricultural productivity, threatening the world's food supply. If current trends continue, it is expected that 30% of the world's water supply will be depleted, and the number of drought-affected regions will more than double by 2050. Plants under drought stress have a reduced ability to absorb water and nutrients, as well as a lower rate of photosynthesis and hormonal balance, as well as an increased accumulation of reactive oxygen species. The degree of the drought, duration of exposure, and growth stage all have an impact on maize yield loss (Balbaa et al., 2022).

In our study, we employed dendrometers to measure plant water stress levels. Dendrometers are tools used in plant physiology to monitor and measure plant growth dynamics and responses to environmental stimuli. Dendrometers have become essential tools in plant physiology research, allowing us to track and quantify plant growth dynamics in real time. They provide vital insights into plant reactions to environmental conditions such as water availability, temperature, light, and mechanical stress by detecting changes in stem diameter or displacement (Clark et al. 2000).

Accurate monitoring of stress manifestations can help to respond adequately to drought, thereby improving the efficiency and utilisation of areas for crop production.

2. Material and methods

Our aim was to monitor stress manifestations under different irrigation conditions and subsequently delineate the dendrological responses of the plants, within which we can adequately respond to stress factors and minimize their impact in the future.

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2.1 Experiment design

The plants were cultivated indoors at a controlled temperature between 20 and 25 °C and a humidity of about 60 %. During cultivation we used LED lighting from MARS HYDRO to simulate daylight. The lighting was set for a 12-hour photoperiod. A DD-S type dendrometer was used to monitor radial changes in the stem of the plant and we fixed it firmly to the stem of the plant. Each plant had one DD-S type dendrometer. The collected data were subsequently stored in a device designed for their collection in a DL 18 dednrometric recorder. Continuous data collection was conducted at hourly intervals from March 15, 2023 - April 4, 2023. Irrigation was delivered to each pot separately, using two 6-channel, DP-6 metering pumps. Plants were divided into 3 groups according to the different irrigation dose, each group consisted of 3 plants. Irrigation was applied at one-day intervals as follows: group 1 was 5ml per plant, group 2 was 2 ml per plant, and group 3 was without irrigation during data collection.

2.1.1 Crop

Zea mays has a distinct plant structure with separate sections that contribute to the plant's overall growth and development, Root system consists of a primary taproot that gives rise to lateral roots that spread far in the soil (Hauck et al. 2015)(Qi et al., 2012). Maze has a sturdy and erect stem that is distinguished by its height, robustness, and nodes where leaves are attached. The stem is the plant's fundamental structural support and promotes the movement of water, nutrients, and carbohydrates between different regions. The hollow and conspicuous internodes of *Zea mays* stems contribute to their flexibility and capacity to endure wind and other environmental stressors (Boon et al., 2012). Leaves are long, slender, and alternating along the stem. Each leaf is made up of three parts: a sheath that surrounds the stem at the base, a blade or lamina that provides the primary photosynthetic surface, and a ligule at the sheath-blade junction. They are arranged in a spiral manner, resulting in a peculiar phyllotaxy that enhances light collection (Evert et al., 1978; Ristic and Cass, 1991). *Zea mays* has separate male and female blooms that are situated on the

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same plant. Tassels, or male flowers, are located at the top of the plant and are made up of multiple tightly spaced branches, each containing spikelets. The spikelets contain anthers, which create pollen grains that fertilize the plant.

Female flowers of *Zea mays* are crowded together in structures known as ears and are borne on the plant's lateral branches. Each ear is surrounded by modified leaves known as husks, which protect the growing kernels. Silks, or female flowers, arise from the ear and act as receptive surfaces for pollen grains. Each silk is connected to a separate ovary, where fertilization takes place, resulting in kernel growth (Lara et al. 2019). Wind facilitates pollination in *Zea mays*, which is known as anemophilous pollination. The development of responsive silks from the ear coincides with the discharge of pollen from the tassels. The pollen grains are carried by the wind to the silks, which capture and direct the pollen tubes to the ovules for fertilization. Pollination and fertilization success result in the production of ripe kernels within the ear (Roy et al. 1995).

Growth and Development can be separated into several stages. The vegetative stage is the period of early growth in which the plant creates its root system, develops leaves, and grows in height and biomass. Rapid cell division and elongation characterize this stage, allowing the plant to catch sunlight and collect nutrients for future reproductive growth.

The start of the tassel and ear primordia marks the transition from the vegetative to the reproductive stage. As the plant matures, it enters the reproductive stage, during which the tassels and ears further distinguish. Tassels produce pollen grains as anthers develop, while ears go through a complex process of silk elongation and kernel development (Vina et al. 2004).

2.1.2 Dendrometric measurements

In our case, we employed dendrometers with electronic calipers, which is a simple and practical dendrometer approach. Electronic calipers measure diameter or displacement by turning physical distance into an electrical signal using moving jaws on opposite sides of the stem. Despite their

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widespread usage in field investigations and greenhouse trials, electronic calipers may be limited in their applicability due to jaw size constraints, which limit their application to lower stem sizes (Drew and Downes, 2009).

Dendrometers were put on maize stems in irrigated and non-irrigated groups. The gadget transforms changes in branch diameter to an electrical signal with a resolution of 4.4 µm per volt and an accuracy of 2 µm in the range of 0 to 11,000 µm. Rubber bands were used to secure the dendrometers to the stems, which did not harm the tissue. The sensor's coefficient of thermal expansion is 0.2 µm K1. Electrical resistance values were measured and recorded automatically every hour with a data logger DL 18. The collected measured data were translated from ohms to µm using Equation: µm = raw data x 4400 (µm)(Bárek et al., 2021).

3. Results and discussion

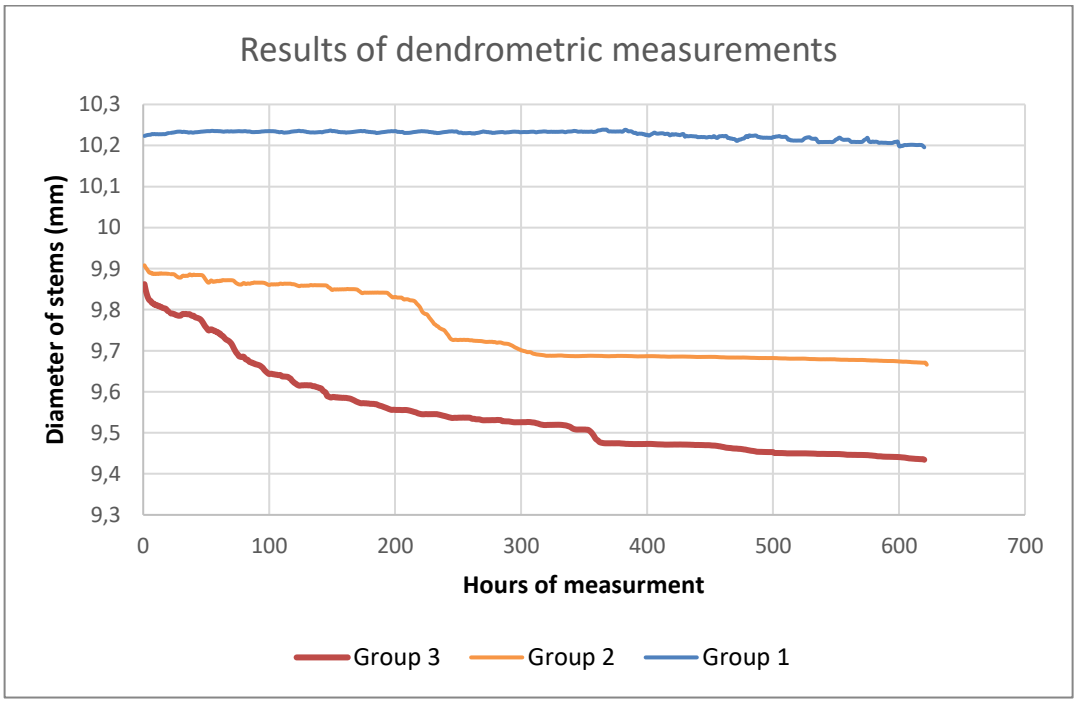

Figure 1 Results of dendrometric measurements.

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Considering the conditions in which we measured the plants, we observed the smallest changes in stem diameter reduction in group 1, where the irrigation rate was set at 5 ml and the stem diameter of the plants was reduced by 0.27 % (from 10.22 mm to 10.19 mm). In group 2, we changed the irrigation rate from 5 ml to 2 ml and as a result of this change, we observed a greater decrease in stem diameter, by 2.44 % (from 9.91 mm to 9.67 mm). In the third group, without irrigation, the stem diameter decreased the most among all groups, by 4.34 % (from 9.86 mm to 9.43 mm).

4. Conclusions

The results show that the DD-S dendrometer accurately detected stress symptoms in plants with sub-optimal irrigation rates and thus we can use its measurements in the future to prevent the negative effects of drought on plant production.

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LOST PLACES IN THE CITY

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Abstract

In every city we encounter places that do not have a clearly defined function. Cities are full of empty plots that have a life of their own. Is filling of free area between two buildings we call them vacant lot. Vacant lot, if they are not built in a short period of time, they become lost places that are out of control and out of order and consequently create green chaos in the city. Which brings a new diversity to the built urban system and the possibility of recreation in close proximity to residential buildings. Vacant lots have become part of the city for many decades and many undeveloped plots of land create an oasis of greenery in the urbanised environment.

People have started to visit such places spontaneously and use them for daily recreation. Often it is no longer possible to bring them back into the city system because people have become accustomed to the greenery in their surroundings and do not always want to exchange it for a new building or a parking lot. A gap full of greenery provides a lot of freedom for visitors to recreate, unlike a city park which is strictly roped off. In such places, animals and plants are beginning to appear in addition to people. Many plants and animals have a presence and a safe territory in the gap until the gap is of interest to urban planners or developers. At that point, the chaos becomes an asset and conservation becomes a priority for its visitors.

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In city centres, we are seeing the emergence of recreational potential that we are trying to foster through low-cost interventions in the urban environment. Which reduce the costs of maintenance, and transport for recreation. And we can bring elements of daily recreation into an otherwise enclosed urban fabric.

Keywords: terrain vague, lost spaces, urban gaps, sustainability, vacant lot

1. Introduction

Cities are ever-changing and dynamic, and one of their defining features is the existence of empty plots of land known as vacant lots. These parcels of land lack a clearly defined function and can often remain unutilized for prolonged periods. In urban settings, these lots may transform into abandoned spaces that are unregulated and disorganized, leading to an overgrowth of vegetation (Epstein Jones, 2017). However, they can also serve as green oases in densely populated areas, introducing new diversity into the built environment and providing opportunities for recreation near residential structures. Public spaces have a great aesthetic role and can complement and beautify the city (Carr et al., 1992). We do not consider as public spaces the areas that are publicly accessible but are not visually interesting or safe, such as pedestrian crossings, parking lots, railway tracks, etc. (Jakušová, 2010).

"Terraine vague'' - They arise because of the constant expansion of cities into the countryside, but also a lack of care for the heritage and history of the post-communist era. As cities expand, vague gaps also emerge in the urban environment, which do not connect with the surrounding landscape and do not communicate with it other than through engineering networks or transport infrastructure (Haluzík (ed.) et al. 2021). The city represents a system in which places and plots are integrated into functional chains and networks that are balanced. However, the city is formed in different phases, and then there is an opportunity to create different gaps that can later start living their own lives (Sádlo, 2019). Empty spaces always arise after the retreat from organization. One significant benefit of vacant lots transformed into green spaces is that they can enhance the visual

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appeal of the community. By introducing trees, plants, and flowers, these lots can add colour and life to the surrounding environment, transforming otherwise dull and uninviting spaces into vibrant and lively places. Additionally, green spaces can contribute to the overall well-being of the community by reducing stress and promoting relaxation. We know exposure to greenery can improve mental health, leading to reduced levels of anxiety and depression (Haluzík (ed.) et. al., 2020). In every city or town, there are places that society does not use, and these places are called by various names because they do not have a clear or precise definition. By their very nature, they provide the observer or visitor with freedom and space for creative perception of such places (Žolobaničová, 2022). Examples - Anxious landscape, Second city, Places of heterotopies, places between places, Urban wildness, Urban jungle, Non places, Blinded spots in urbanism, Lost places, White places, Sub natural, The third landscape. All of these are names for vague places in urbanism. They are worlds unto themselves, with unique non-urban creations, are considered part of the official image of the city, yet they are omnipresent (Žolobaničová, 2022). They are places that have fallen outside the character of the city (Foucault, 1967). Lost places are located within the city and line our daily trajectories of urban travel. They lie close to our homes and create a visible background for us. Lost places fulfil a predominantly eco-stabilising function in the city. Many perceive them negatively or not at all (Prochnow & Čibik, 2022). According to theorists, the phenomenon called vague space is linked to urbanism. Vague space is an essential product of urbanism, and while it may be an unintended expression of it, it is necessary and cannot be avoided (Šturma, 2015).

2. Material and methods

Lost spaces research is a complex project that consists of four parallel activities:

a. Mapping
b. Analysing
c. Concept
d. Design

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Mapping takes place in the field through direct observation methods. The basic basis for mapping is a set of well-processed historical analyses and related map materials. To achieve this objective, a range of map materials, spatial planning materials, a country atlas, as well as field surveys and our own photo documentation of the cadastral territory of Nitra and its immediate surroundings were necessary. We created a method for site evaluation, which we applied to the city of Nitra. Organized vague spaces: They represent a set of certain rules. For the place, they are tolerated in surroundings, but not frequented. Unorganized vague spaces: They have no function in the urban structure. Empty, chaotic places left to their own fate, waiting to be restored to at least a temporary function

The sample area we chose is the oldest and most inhabited part of the city, characterized by architectural diversity and a high number of urban voids. This area encompasses the historic city center, block constructions, multifunctional buildings, modern urbanism, parks, and alleys. Urban voids come in various forms and sizes, ranging from small, neglected remnants of land left unmanaged to large, abandoned ruins in city centers. Methodologically, we employed methods such as the "Methods of evaluating public spaces 2015 (Vitková, 2015), supplemented by the "Pixel method" (Žolobaničová, 2022) and the "Methodology of green and blue infrastructure applications" (Haluzíková, 2020), Haluzíková divides white spaces into organized vague spaces and unorganized vague spaces. Along with the place-making living places, it is possible to evaluate and compare all the places included in the working database and to perceive their immediate surroundings through the methods of comparative research.

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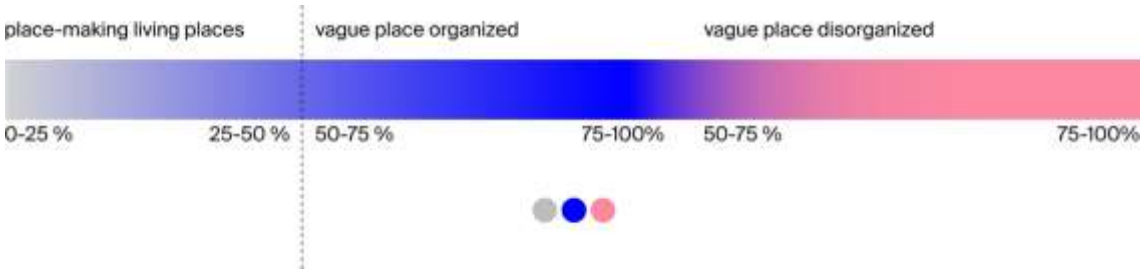

Figure 1 Graph of vagueness intensity (Haluzíková, 2020)

3. Results and discussion

The research will interpret the possibilities of future use of such spaces in an innovative form, especially by graphic outputs, through various case studies applied to the specific areas, which will significantly simplify the process of restoring function as a result. The professional aim of the research is to create a typology of the territories included in the working database and the phasing of their potential temporary, short-term, or long-term use regarding financial and spatial possibilities. In duration of the research, these spaces will be gradually "occupied" through participatory processes.

Case study of exemplary urban void in Nitra Mostná numbers 62 and 66. The current state of the selected location can be described as an abandoned space near in the centre of the urban system. These places have peculiar non-urban characteristics, even though they are not full-fledged public spaces. They are characterized by chaos, disorder, mixed vegetation, unattractiveness, and abandonment. It is not uncommon to find litter there. They have no dominant architecture or vegetation. The proposal is to modify these places into a basic aesthetic form - by introducing organization, order, and offering them to citizens for recreation.

We categorized the possibilities of application and described them methodically - these are applications that have a favourable impact on the environment and are the first point of improvement in the selected locality. Based on the placement of these applications, the space can

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be further categorized and elements characteristic of closer requirements can be placed in it during interventions or landscape-architectural design. In organized passageways or inner courtyards, it is important to find a function again and make the places accessible or available.

The pixel analysis shows us that the space needs to be integrated into the urban system with permeable surfaces, retention beds, a more resilient herbaceous layer, and the planting of trees that are more suitable for the urban environment, as well as cultural vegetation. It is a very attractive place that is currently unused and empty. In a detailed design, the space will be complemented with flower beds, permeable surfaces, a tree-lined avenue, furniture, and a visual kinetic-optical element.

Figure 2 Axonometries design urban avoids Mostná 62 and 66.

We found that urban avoid provide a habitat for a diverse range of plants and animals, contributing to the urban biodiversity. These spaces can serve as breeding grounds for native species, including birds and insects, and provide a haven for animals that are displaced by urban development. However, vacant lots of face challenges associated with their management and maintenance. The lack of ownership and control over these spaces often leads to neglect and illegal dumping,

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contributing to the creation of green chaos in the city. Moreover, vacant lots can become a safety hazard if left unattended for an extended period, leading to criminal activities and vandalism. To overcome these challenges, the study recommends the implementation of low-cost interventions in the urban environment that promote the sustainable use of vacant lots. These interventions include the establishment of community gardens, the creation of temporary public spaces, and the installation of lighting and other safety measures. To change and update something means having the ability to understand the dynamic and living nature of our settlements. The balance between open spaces and structures, private and public spaces, and individualism and socialization can change over time. We are now moving into a new era where planning should focus on human beings and our health, as well as the health of the planet (Back Prochnow, Čibik, 2022). Currently, city centres are paved, but in the Middle Ages, they were full of unregulated terrain. The surfaces were hardened with a thin layer of sand, twigs, or old wood at most. In places where there was not much traffic, ruderal vegetation grew, which then led to an increase in biodiversity (Pokorná, 2016).

In conclusion, the paper highlights the importance of urban avoids as an essential component of urban green spaces. The sustainable use of these spaces can contribute to the creation of a more liveable, sustainable, and resilient city.

4. Conclusions

The city is not always homogeneous; it is composed of multiple places, and each city has its own secrets, waiting to reveal its potential. Italo Calvino believed that every city is made up of invisible places that form its character. Urban identity is not based on just one place, but on the entire society (Calvino, 1997). Currently, society focuses mainly on public spaces, parks, urban and suburban landscapes. However, lost places escape our attention, providing opportunities for development (Witting, 2004). Urban gaps bring wilderness into the hearts of cities. The phenomenon of vacant space, lost places, and urban avoidance is related to urbanism. These

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places are an integral product of urbanism, although an unintentional expression, and therefore, inevitable (Haluzík (ed.) et. al., 2020). Architect Michal Fisher, who, after completing his studies, was left with remnants of the Berlin Wall, commented on these places as areas where traditional urban planning rules do not apply, where plants grow, and the city's inhabitants visit, even where decay should prevail, and development should not occur (Meduna, 2012). In cities, various accessible corners, incomplete spaces, or brownfields remain where abandoned walls of pure concrete or metal panels decay, as if life has vanished from these places, and they seem to belong to no one. However, when the community focuses on them, they can bring them to life, attracting new visitors (EZOP 257, 2016). Biologist Jiří Sádlo says that "the centre represents order, and the periphery represents chaos," but order arises from chaos, and the centre always tries to maintain decorum. In contrast, peripheries have their own order in chaos, having civilized themselves in their own way without the need for architects. Thus, a subnatural landscape opens up to us, which we only need to visit (Sádlo, 2019). It is considered a space that develops on its own and in the long term can be regarded as a genetic reservoir or ark of the planet and a space for the future (Clément, 2016). An example of this can be seen in the city of Pripyat in Ukraine, which was devastated by radiation following the Chernobyl nuclear power plant accident. Nature found its way in this place, and the landscape was able to adapt on its own. The city lost its primary function, but the landscape itself joined the chaotic flow of nature (Attenborough, 2020). From a perspective point of view, it matters. A vague terrain from a human perspective is not equivalent to a vague terrain from a snail's perspective. Nature is naturally mosaic and a natural mosaic has also been created within the constructed city. It is natural for snails to live and migrate within different islands in the landscape. Within them, they move and explore the surrounding world, and for city life, this is a remarkably apt analogy (Cameron, 2016). Various experts speak of the recreational potential of these places urban gaps, but in practice, we see that we have not yet dared to discover it. It is a different, wild world, but it works and brings a new dimension to the city's society.

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Figure 3 Organized in the past terrain vague. Bratislava, SK

Integrating these spaces into the urban fabric and creating modular solutions to urbanize them provides a unique opportunity to efficiently enhance public spaces and collaborate with the surrounding environment. Urban avoids can also attract various species of plants and animals to inhabit these areas. Lost spaces, vague terrains and urban avoids have become a second world within the city, a different, wilder world that bring a new dimension of urban recreation.

Some places in masterplan are meant to be "empty" to allow the entire urban landscape to breathe (Back Prochnow, Čibik, 2022). But when they are empty for too long, they begin to go crazy and become unruly within the city system, and we cannot use them. Urban avoids full of nature provide us with new spaces to communicate with greenery. As active participants in urban life, we are not passive recipients of the surrounding events. We actively participate in the events and processes that take place in these urban avoids. The principle of returning function to urban avoids offers us recreational spaces in the centers of cities.

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THE LABORATORY INVESTIGATION OF *CURCUMA LONGA L.* ESSENTIAL OIL AS REPELLENT AGAINST KINDS OF ORCHARD APHIDS

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Abstract

The aim of the study was to find the potential repellency of *Curcuma longa* L. essential oil (EO) and two chemical substances DEET, (N, N-diethyl-3-methylbenzamide) and 2-Undecanone on *Aphis pomi* DeGeer., *Dysaphis plantaginea* Passerini and *Myzus cerasi* F. Repellent peculiarities were evaluated at five different concentrations – 0.3%, 0.6%, 0.9%, 1.2% and 1.5%, with 4 replications at the interim of 15 and 30 minutes for an olfactometer test. Results showed that repellency was increased with increasing the concentration and expecting time. The results showed that the volatiles from *C. longa* at 30 minutes, significantly repellent to aphids in an olfactometer. The strong repellent activity was recorded on *Aphis pomi* (2.25 pcs.). We concluded that the EOs may have potential as an alternative to chemical control, and therefore, they could be included into integrated pest management of aphids, in the Europe and all over the world.

Keywords: repellent, olfactometer, aphids, essential oils.

1. Introduction

Aphids are one of the foremost dangerous bugs of almost all developed crops. Given their brief life

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cycle, aphids can have as numerous as 40 generations or more annually beneath optimal conditions, which suggest that theoretically, one female can deliver billions of relatives yearly, in the event that there's no mortality (Dedryver et al. 2010). In addition to debilitating the plant by sucking sap, frequently coming about in leaf distortions, aphids act as vectors for various plant viruses (Jarošová et al. 2016).

In the modern world, there is a rapid increase in the number of aphid populations, which is the result of a successful combination of intensification of technologies in crop production, monoculture and climate change, which all together creates a favourable environment for the growth of the number of these insects (Blackman and Eastop 2017).

Pyrethroids, neonicotinoids, carbamates and insect growth regulators are the classes of active substances that are the basis of chemical plants protection products against aphids. However, in the control against aphids, insecticides do not always provide a reliable result, since insects are already resistant to some classes of insecticides, and the fight is complicated by the fact, that aphids often feed on the underside of leaves (Bass et al. 2014).In addition, the use of some synthetic insecticides or their residues can be dangerous to non-target organisms, including humans (Costa 2018).

This is the reason for the search for new alternative ways to resist damage to plants by aphids. Currently, botanical insecticides (BIs) based on the insecticidal efficacy of secondary plant metabolites are considered a suitable alternative for plant protection against pests (Ofuya et al. 2023) including aphids. The BIs are usually produced from extracts of medicinal plants or plants used in the food industry, and they are viewed as products associated with minimum health and environmental risks. Highly promising plant metabolites with useful insecticidal activities also include the group of plant essential oils (Ikbal, C. and Pavela, R. 2019).

Turmeric essential oil is one of the promising oil in the system of plant protection (Divekar 2023; Islam et al. 2020; Lee et al. 2001; Salama et al. 2023), and at the same time, not well studied enough. *C. longa* (turmeric) is a small rhizomatous perennial herb of Zingiberaceae (Ginger family) originating from south-eastern Asia, most probably from India. The plant produces fleshy rhizomes

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of bright yellow to orange colour in its root system, which are the source of the commercially available spice turmeric (Damalas 2011; Singh 2017).

The EOs, extracts, and curcuminoids extracted from Curcuma species have been found effective against a wide range of microbial pathogens and pest insects damaging food crops, either in storage or in the field (Abdelmaksoud et al. 2023; Golafshan & Dorosti 2015; Hasan et al. 2021; Vázquez-Aguilar et al. 2023;). The fresh juice, water extracts and essential oils of *C. longa* show insecticidal activity against insect pests and act as mosquito repellents (Said et al. 2015; Uzair et al. 2018).

Research efforts so far and data from the international literature have shown a satisfactory potential of turmeric as a natural repellent/pesticide for possible use in crop protection and thus a highly promising future towards this direction, that is, the possibility of effective control of certain pests of agricultural importance with the use of turmeric products as a cheap and more environmentally friendly alternative to chemical pesticides already used for the same purpose.

All the above-mentioned served as a driving mechanism for our research. We have decided to find the appropriate concentration of curcuma essential oil, which will provide good/excellent repellent effectiveness against three types of aphids – rosy apple (*D. plantaginea*), black cherry (*M. cerasi*) and green apple (*A. pomi*).

2. Material and methods

2.1 Basic experiment information

This study was carried out at the Laboratory of Entomology, Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra. The experiment included "two-choice olfactometer" repellency tests with C. longa and two chemicals against three types of aphids. The study was carried out under the laboratory conditions at the temperature of 20 ± 1 °C, humidity 50 ± 1 %, and /light/dark 16:08/ h.

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2.2 Insects used

Parthenogenetic populations of aphids were collected from apple and cherry cultures infested by aphids at a local field of the crop garden in Nitra (Slovakia) 48°18'16.7"N 18°05'41.3"E in June 2022. Nutrients were fresh host plant leaves. Approximately 10000 adults were incubated at 9 ± 1 °C and 50 % relative humidity (RH) under a long day (16:08 hours) in plastic boxes (22 cm diameter x 13 cm height). Insects were maintained in plastic containers that were lined on the bottom with moist tissue and covered with a tight lid to avoid early drying of the leaves. The adults of both sexes of different age were used in the experiments.

2.3 Essential oils and chemical substances used

Essential oils were obtained from a Mystic Moments Inc. (UK) as commercial essential oils. In the *C. longa* essential oil were founded (by chemical analysis) the chemicals phellandrene and turmerone, which were the most effective against insects. Chemical substances were obtained from Sigma-Aldrich Company (DEET (N, N - diethyl - 3 methylbenzamide) in 97 % concentration; 2-Undecanone (methyl nonyl ketone) in 99 % concentration.

2.4 Laboratory Bioassay

Frist "two-choice olfactometer" test of *C. longa* on *D. plantaginea, M. cerasi* and *A. pomi*

"Two-choice olfactometer" test was used in the experiment. An EO of *C. longa* and two chemical substances were used in the experiment with the three species of aphids (*D. plantaginea, M. cerasi* and *A. pomi*). Four replicates were used for each tested dose (0.3%, 0.6%, 0.9%, 1.2% and 1.5%). Liquids for the experiment were prepared by diluting each EOs and chemicals with 10 ml acetone (v/v). The experiments were conducted using a Y-tube-olfactometer. A 10 µl of each solution was dosed on a piece of filter paper (ADVANTEC, No. 2, 10×20mm), odour sources were placed in the treatment arm, and a filter paper treated with 10 µl of acetone was placed in the control side. In each arm used one leaf of the apple tree as aphids' food. The three species of aphids (*D. plantaginea, M. cerasi* and *A. pomi*) were released individually into the olfactometer using flexible

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forceps. The air was taken with the help of standard compressor and it was filtrated with an air delivery system. The total airflow for each chamber was 300-400 ml per minute. The measurements were done after 15 and 30 minutes. The aphids were moved to treated and untreated arms from the release point at 10 cm distance to the Y-junction. The choices of the aphids were recorded. Each replicate consisted of 20 responding aphids (= total 240 of all three aphids) per three treatments. Odour sources (chemicals and EOs odours) were replaced after each replicate. Experiments were conducted at temperature 20°C and relative humidity 50 %. Absence of aphids in treated arm leaves was considered a repellency effect (repellence=oriented movement away from a stimulus).

3 Results and Discussion

We have started our experiment (the scheme of experiment is in the Table 1) form verification of curcuma essential oil (*C. longa*) on three types of aphids – rosy apple (*D. plantaginea*), black cherry (*M. cerasi*) and green apple (*A. pomi*), using 5 levels of oil concentrations in the olfactometer (Table 2).

Table 1 The scheme of the experiment. EO from *C. longa* was used to repel the aphids: rosy apple (*D. plantaginea*), black cherry (*M. cerasi*) and green apple (*A. pomi*).

Factor A – concentration, %	**Factor B – time after treatment, min**	**Factor C – Aphid's species**
1. 0.3	1. 15	*D. plantaginea (rosy apple)*
2. 0.6	2. 30	*M. cerasi* (black cherry)
3. 0.9		*A. pomi* (green apple)
4. 1.2		
5. 1.5		

Source: made by authors based on the own research

The average amounts (after 4 replications) of aphids are shown in the table 2. This means that for

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experiment we took 5 insects, and after the placement of odour source and insects in olfactometer, checked the amount of insects on the treated by EO side (tube) of olfactometer (second tube of olfactometer contained cotton pad without odour source). The concentration amplification influenced on the movement and thus on the appearance of repellent peculiarities of curcuma EO.

Table 2 The effect of *C. longa* essential oil concentrations and waiting time on the movement of aphids in the two-choice olfactometer test

Concentration, %	Time after, min	Variation indexes		Data variation, %	RI, %
		Average amount, pcs. X±Sx	Standard deviation, S		
D. plantaginea (rosy apple)					
0.3	15	4,500	0,577	1,28	10
	30	3,750	0,500	1,33	25
0.6	15	3,750	0,957	2,55	25
	30	4,000	0,816	2,04	20
0.9	15	2,750	0,500	1,82	45
	30	2,000	0,816	4,08	60
1.2	15	1,500	0,577	3,85	70
	30	1,250	0,500	4,00	75
1.5	15	0,250	0,500	20,00	95
	30	0,750	0,500	6,67	85
M. cerasi (black cherry)					
0.3	15	4,250	0,500	1,17	15
	30	4,000	1,155	2,88	20
0.6	15	3,250	0,957	2,94	35
	30	3,000	0,816	2,72	40
0.9	15	2,000	0,816	4,08	60

 DOI: https://doi.org/10.15414/2023.9788055226217

	30	1,500	1,000	6,66	70
1.2	15	1,250	0,500	4,00	75
	30	1,250	0,957	7,65	75
1.5	15	0,750	0,500	6,66	85
	30	0,750	0,500	6,66	85
A. pomi (green apple)					
0.3	15	4,250	0,957	2,25	15
	30	4,500	0,577	1,28	10
0.6	15	3,500	0,577	0,00	30
	30	2,750	0,957	3,48	45
0.9	15	2,500	0,577	2,31	50
	30	2,000	0,816	4,08	60
1.2	15	1,500	0,577	3,85	70
	30	1,000	0,816	8,16	80
1.5	15	0,500	0,577	11,55	90
	30	0,500	0,577	11,55	90

Source: made by authors based on the own research

Thereby these numbers allowed us to calculate the repellency index of curcuma essential oil. Repellency index (%) is the dimension which shows how does some substance repel / not attract insects. According Saxena & Sayyed (2018) C. longa EO showed 73% RI. The highest RI – 95%, according our observation, was received at concentration 1.5% after checking the olfactometer in 15 min when it was applied for *D. plantaginea (rosy apple aphids)*. Also good RI value – 90% were achieved at the same concentration (1.5%) after 15 and 30 min when curcuma EO was applied for *A. pomi* (green apple aphids). When EO was applied for *M. cerasi* (black cherry aphids) the highest RI – 85% were observed at the same concentration – 1.5%. The lowest values of RI, which is expectable, were noticed at the lowest concentrations. Similar results were observed by Cheng et al. (2020) and Azeem et al. (2020) were investigated the antifeedant activity of curcuma EO. In

 DOI: https://doi.org/10.15414/2023.9788055226217

every case this oil showed good results.

The application of correlation-regression analysis made it possible to construct correlation fields with polynomial, linear and logarithmic trend lines (Figures 1-3) and make mathematical models of dependences between the concentrations of *C. longa* EO and investigated types of aphids (Table 3).

The given images allow us to make possible conclusions that there is strong negative connection between concentrations of *C. longa* EO and amount of aphids.

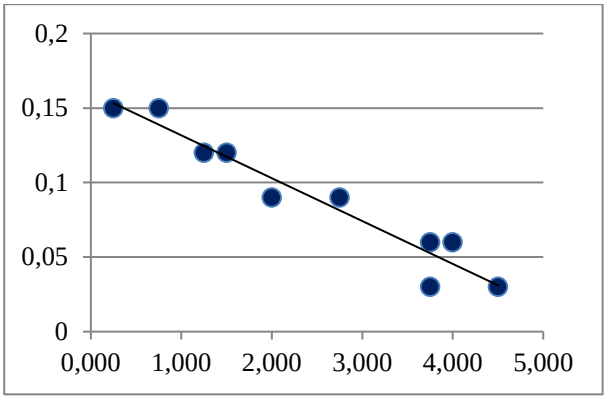

Figure 1 The correlation field between average amount of rosy apple aphids (X) and concentration levels of *C. longa* EO (Y). Source: made by authors based on the own research

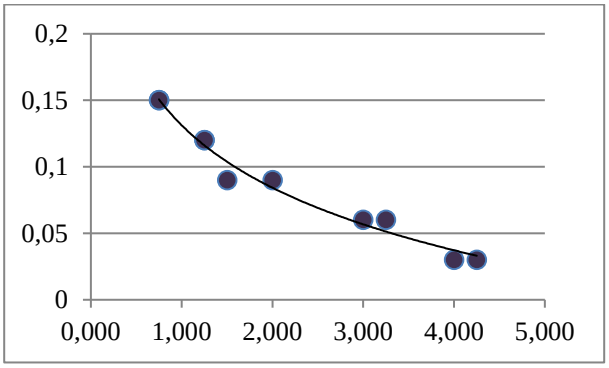

Figure 2 The correlation field between average amount of black cherry aphids (X) and concentration levels of *C. longa* EO (Y). Source: made by authors based on the own research

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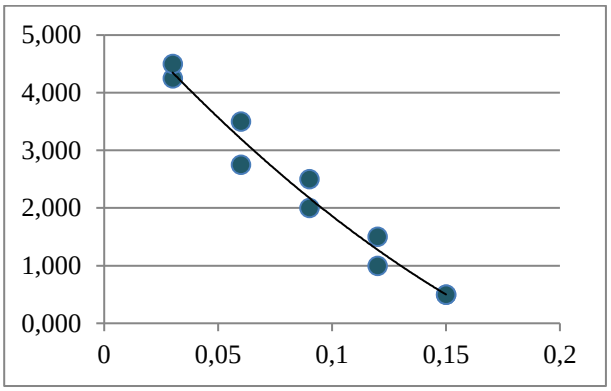

Figure 3 The correlation field between average amount of green apple aphids (X) and concentration levels of *C. longa* EO (Y).
Source: made by authors based on the own research

Table 3 Mathematical models of the influence of curcuma oil concentrations and waiting time on the number of aphids (in the olfactometer)

Index	Regression equation	Correlation coefficient, r	Determination coefficient, R^2
D. plantaginea (rosy apple)			
concentration	y = -0,0287x + 0,1604	-0,966	0,92
M. cerasi (black cherry)			
concentration	y = -0,068ln(x) + 0,1312	-0,972	0,94
A. pomi (green apple)			
concentration	$y = 69{,}444x^2 - 44{,}583x + 5{,}625$	-0,981	0,96

Source: made by authors based on the own research

For statistical assessment of experiment we were used the correlation and determination coefficients, which shown that the correlation between concentrations of curcuma EO and number of all three types of aphids had strong negative connection; for simple conception it is mean that the amount of aphids depended from concentration, in the increasing of its was decreasing of individuals amount. One of the indicators describing the quality of the built model in statistics is the coefficient of determination, which is also called the approximation reliability value. R^2 numerically shows how much of the variation in the dependent variable is explained by the model.

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Indicates how well the obtained observations confirm the model. In the conditions of classical linear multiple regression, the coefficient takes a value from 0 to 1. It is believed that the closer the coefficient is to 1, the better the model is. Depending on the level of the coefficient of determination, it is customary to divide the models into three groups: 0.8-1 – a good quality model; 0.5- 0.8 – a model of acceptable quality; 0-0.5 - poor quality model. With regard to this we can assess our models as models with good quality and in this case the quality of the model indicates the possibility of using it for forecasting.

The three-factor variance analysis of data was done (Figure 4). According the received calculation was founded that factors B and C, exactly time after treatment and type of aphid don't effected on the moving and amount of aphids – the power of influence was 0. The combination of concentration and time after treatment (AB) showed the power of effect – 1 %. The power of influence merely concentration (A), % of essential oil was 57 %. Obtained results depend from combination of concentration of EO, % and aphid's species (AC) on 2 %, from combination of time after treatment, min and aphid's species (BC) – on 1 %. The power of influence on obtained results caused by interaction of all three factors was not significant and constituted 4 %.

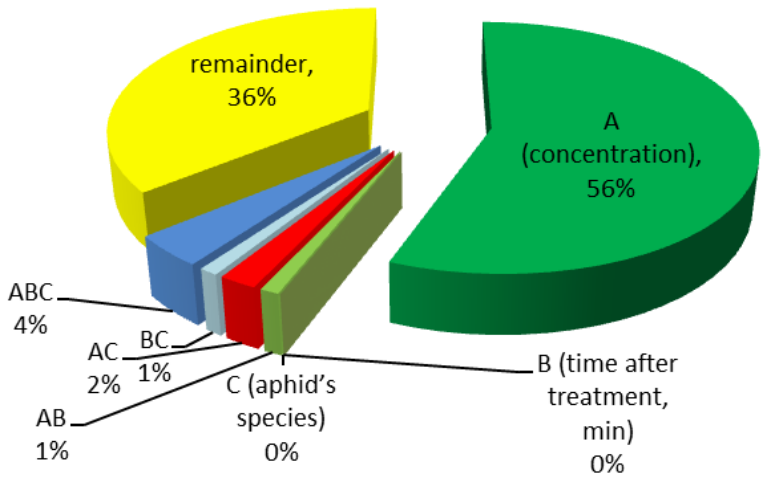

Figure 4 The power of influence caused on the movement of aphids – *A. pomi*, *D. plantaginea* and *M. cerasi* done by investigated factors (%) Source: made by authors based on the own research

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Figure 5 The average amount of *A. pomi*, *D. plantaginea* and *M. cerasi* through experiment depending on the effect of concentrations and time after treatment. Source: made by authors based on the own research

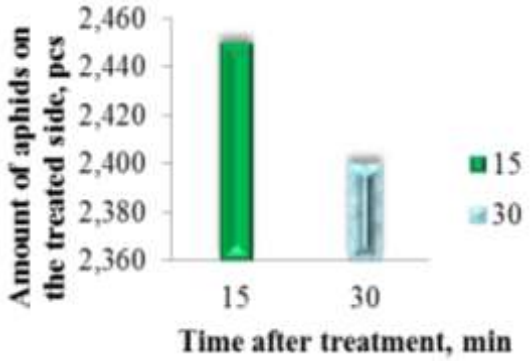

Figure 6 The effect of time after treatment on the amount of *A. pomi*, *D. plantaginea* and *M. cerasi* through experiment. Source: made by authors based on the own research

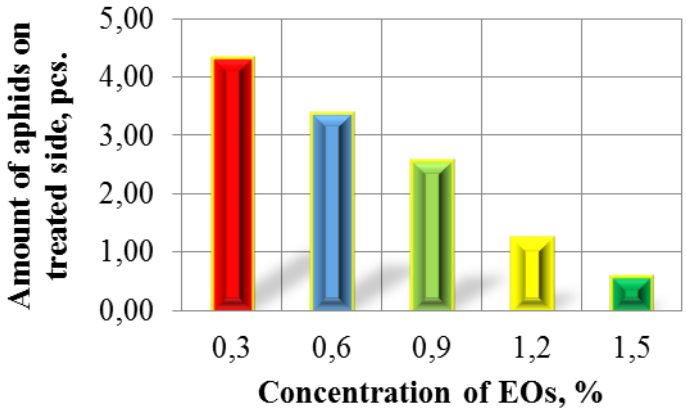

Figure 7 The effect of *C. longa* EO concentrations on the amount of *A. pomi*, *D. plantaginea* and *M. cerasi*

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through experiment. Source: made by authors based on the own research

According this calculation is possible to conclude that the lowest amount of insects – 0.58 pcs was founded at the highest concentration – 1.5 % (Figure 7), this arrangement of the obtained data corresponds to the data obtained from the previously conducted correlation analysis, and that is, the concentration of essential oil has an effect on the number and movement of insects. If analyse the time factor, it is visible that the lowest amount of insects – 0.240 pcs was founded after 30 minutes of treatment (Figure 6), and the smallest amount of insects was demonstrated by green aphids – *Aphis pomi* – 2.25 pcs (Figure 5).

The Tukey HSD test was used to find statistical significances between investigated factors; the results are shown in the Table 4.

Table 4 Tukey HSD p-value at 0.05 and 0.01 inferences for *C. longa* olfactometr test against three types of aphids – *A. pomi*, *D. plantaginea* and *M. cerasi*

Concentration, %	Time, min	Concentration, %						
		0,6	0,9	0,9	1,2	1,2	1,5	1,5
		Time, min						
		30	15	30	15	30	15	30
0,3	15		**0.0181 p*;** **0.0136 b*;** **0.0464 g***	0.0010 p**; 0.0013 b**; 0.0039 g**	0.0010 p**; 0.0010 b**; 0.0010 g**	0.0010 p**; 0.0010 b**; 0.0010 g**	0.0010 p**; 0.0010 b**; 0.0010 g**	0.0010 p**; 0.0010 b**; 0.0010 g**
0,3	30	**0.0464 g***	**0.0399 b*;** **0.0141 g***	**0.0181 p***; 0.0010 g**; 0.0044 b**	0.0010 p**; 0.0010 g**; 0.0013 b**	0.0010 p**; 0.0010 g**; 0.0013 b**	0.0010 p**; 0.0010 g**; 0.0010 b**	0.0010 p**; 0.0010 g**; 0.0010 b**
0,6	15		0.0010 p**;	**0.0181 p***	**0.0399 b*;** **0.0141 g***	0.0399 b*; 0.0010 p**; 0.0010 g**	0.0010 g**; 0.0010 p**; 0.0044 b**	0.0010 p**; 0.0010 g**; 0.0044 b**

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0,6	30			0.0044 p**;	0.0010 p**	**0.0464 g*;** 0.0010 p**	**0.0136 b***; 0.0010 p**; 0.0039 g**	**0.0136 b***; 0.0010 p**; 0.0039 g**
0,9	15						**0.0141 g***; 0.0010 p**	**0.0141 g***; 0.0044 p**
0,9	30						**0.0181 p***	

* Tukey HSD inferences at **p<0.05**; ** Tukey HSD inferences at **p<0.01**;

g – green apple aphids *A. pomi;* **p** – pink apple aphids *D. plantaginea*; **b** – black cherry aphids *M. cerasi*.

4 Conclusion

A search of the scientific literature showed that the essential oil of turmeric, as well as the powder from the roots of the plant, have long been known for their insecticidal effect, while we did not find any studies on the effect of the essential oil solution on *D. plantaginea* Passerini, *M. cerasi* and *A. pomi*, in this context, this research has scientific novelty and relevance. Thus, according to the results of our research on the effect of curcuma essential oil on aphids, it was established that there is a persistent negative correlation between the increase in the concentration of the essential oil in the solution and the decrease in the number of insects in the treated part of the olfactometer. Therefore, in this way, turmeric essential oil shows good repellent properties against garden pest species.

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SIMULATION OF THE INFLUENCE OF GREEN INFRASTRUCTURE ON THE FLOOD FLOW OF THE LYBID RIVER, KYIV

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Abstract

The object of the study is the Lybid River and its catchment, which is located on the territory of Kyiv, Ukraine. The catchment's land cover was categorized and the percentage of impervious area was estimated. Territories that can undergo a complex change with the installation of green infrastructure were pre-selected. With the help of the HEC-HMS program, the estimated flood passage caused by the passage of 17 mm of rain was simulated. It was determined that covering 5 % of the catchment area with green infrastructure will reduce the peak of the flood by 9 %. At the same time, the model did not show a noticeable increase in the time of onset of the flood peak. This can be caused both by the peculiarities of the passage of floods in the urban and hilly conditions of Kyiv, and by the limit of the applied method SCS-CN.

Keywords: Green infrastructure, runoff modeling, Curve Number method, peak flow, urban river

1. Introduction

Modeling water flow in urban conditions is becoming an increasingly important task. Its implementation is necessary for the development of stormwater management plans, risk

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assessment of negative hydrological phenomena and damages caused by them. Separately, it is worth highlighting the evaluation of the effectiveness of green infrastructure to mitigate negative effects or trends. This in turn leads to the need to model how water flow varies depending on different surface types.

The purpose of this work is preliminary modeling of the passage of a flood in real conditions and under the conditions of implementation of green infrastructure. This is necessary to determine the perspective of further research and development of the city in the context of the implementation of green infrastructure. The object of the study is the city of Kyiv, Ukraine. The city has an extensive river network, different types of urban spaces, but does not have a sufficient volume of data on small rivers. The suitability of using SCS-CN method at HEC-HMS program for these purposes in the conditions of Kyiv was also assessed.

2. Material and methods

The city of Kyiv, Ukraine, has an extensive river network. One of the main basins is formed by the Lybid River with its main tributaries, including Klov, Skomorokh, Horikhuvatka and others. It covers an area around 67 km^2, which is 8 % of the total area of the city.

Despite the rather large catchment area, stationary hydrological observations are not carried out on the Lybid River and its tributaries, and there is very little information on measurements and modelling of the maximum flow. The inconsistency of available official data with real ones was noted by a number of researchers, including Vyshnevskyi V.I. (2013), who also noted the impracticality of using the flow module taken from maps of the scale of the region for the rivers of Kyiv. The lack of data creates obstacles for assessing the state of the river, carrying out engineering works in the channel, for sustainable management of the river basin, as well as for assessing hydrological risks and water quality (Bortnyk et al., 2016). This is especially important in view of the large number of objects located in the immediate vicinity of the mentioned rivers.

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For the modeling was used SCS-CN method, which bases on the Curve number (CN). CN is a function of hydrologic soil group (HSG), cover type, treatment, hydrologic condition, antecedent runoff condition and impervious area in the catchment. It is dimensionless and can vary from 0 to 100, where "100" means that all the precipitation turned to surface runoff and no infiltration occurred, "0" means an absence of the runoff, all precipitation infiltrates. In order to obtain this parameter, it is necessary to use special tables, which is possible to find at the U.S. Hydrologic Engineering Center manuals (2000) and in literature (McCuen, 2005), with further refine using assessment of soil, land cover, etc.. CN for impervious surfaces for simulation is defined as 98 (Pandit and Regan, 1998).

The application of this method is rarely found in the scientific literature of Ukraine. At the same time, similar assessments were conducted in neighbouring countries, in particular in Poland and Slovakia (Rutkowska et al., 2015; Vojtek and Vojtekova, 2019), so there is a possibility that this method will be more widely used in the future.

For this study, curve numbers were determined using a combination of official tables, open maps of land use categories, satellite images and photos from the city, and scientific articles describing the city's soils. Data analysis was performed using QGIS.

Turf-podzolic soils are widespread in the western part of the studied area; central part is mostly covered with urban soils. The fragmented erosion network, which occupies part of the Lybid basin, is characterized by a particularly large variety of soil types and vegetation (Bortnyk et al; 2016*). Natural soils were conditionally assigned to hydrological soil group C, while urban soils CN were determined with additional consideration of current state of the surface. Cover types and corresponding approximate determined values of CN are shown in Table 1.

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Table 1. Cover types and their CN value for Kyiv

Cover type	Curve Number value
Roads	98
Buildings	98
Paved area	98
Water surface	100
Grass plot	80-81
Green zones	70-75
Urban soils	89-94
Other	83

3. Results and discussion

Figure 1 presents the classification of the land cover for the Lybid River basin, on the basis of which the averaged CN and the percentage of impervious territory were subsequently determined. The percentage of impervious surface is about 32.5% of the total watershed area. Of the remaining 67.5 percent, only slightly more than 13 percent are occupied by well-organized parks, squares, wooded areas or natural green areas. However, it is worth noting that due to the large area of the studied territory and the lack of a single official source, which complicates manual determination, a significant part of the scattered green spaces was not determined separately, but averaged.

For this work, zones that can be developed by implementing green infrastructure were pre-determined. New residential complexes, public institutions of a large area (such as schools, hospitals), wastelands, clusters of garages, large paved areas etc. were considered. The territory with a total area of about 363 hectares has been allocated, which is 5.3% of the total area of the Lybid river basin. Their distribution across the basin is presented in Figure 2. It is worth noting that the potential of the studied area is not limited to certain areas, and at the same time, due to the lack of physical examinations, it is not possible to guarantee the possibility of implementing Green Infrastructure on them to full extent. For the purposes of this work, they were chosen as simulation of potential changes.

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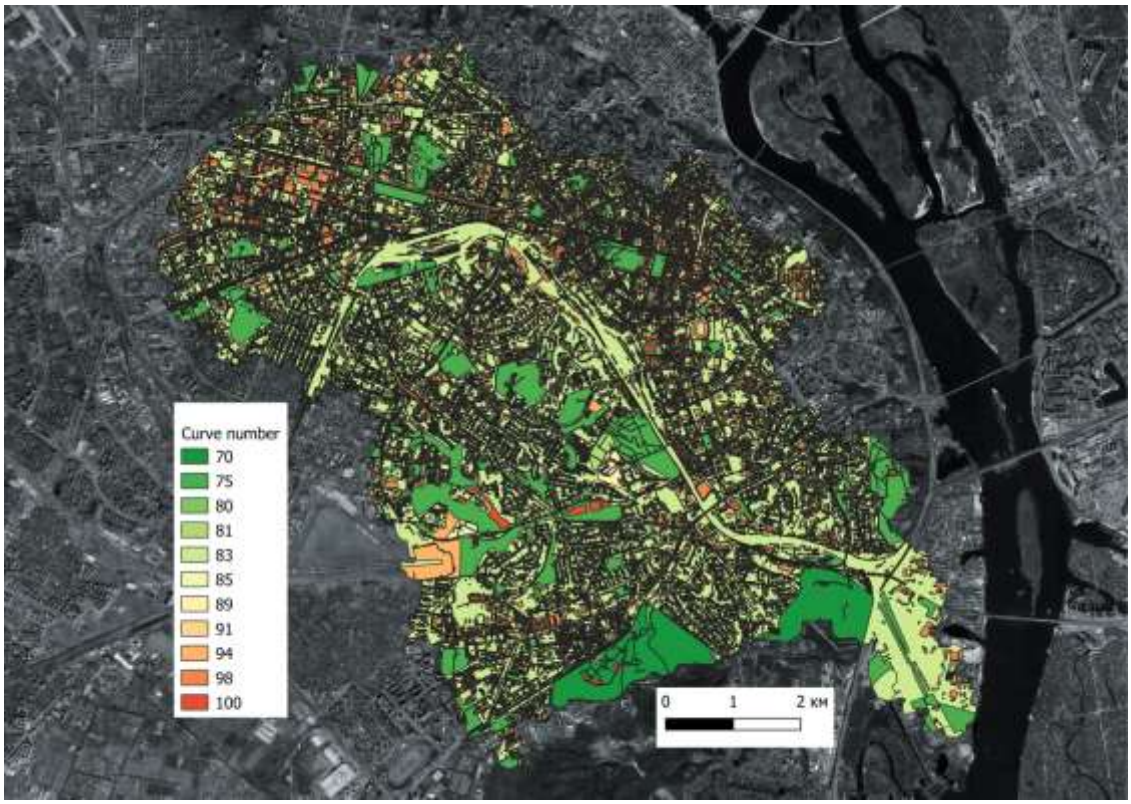

Figure 1 The current classified surface type within Lybid river basin, Kyiv

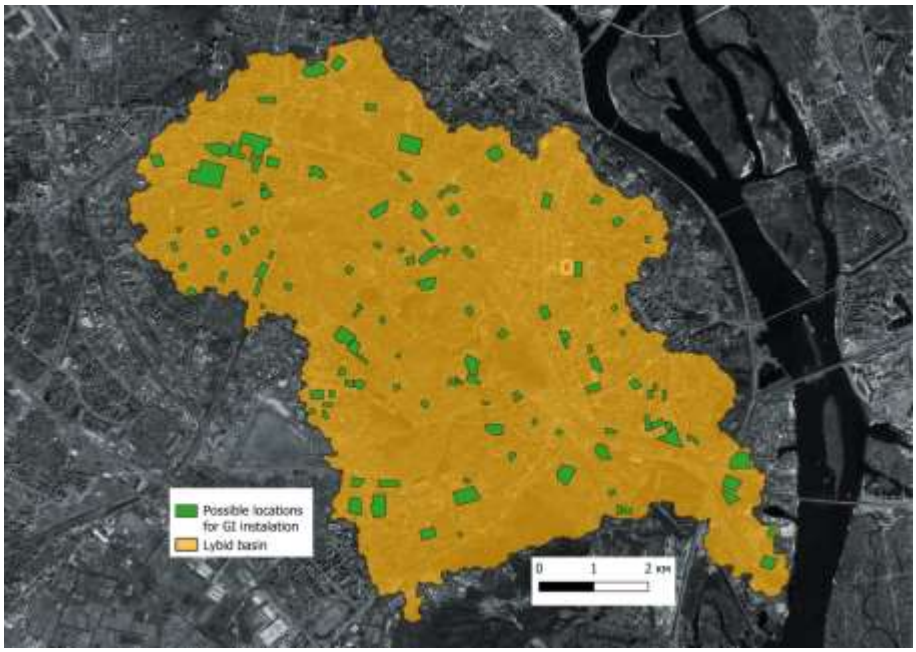

Figure 2 Possible zones for installation of green infrastructure within the Lybid river basin, Kyiv

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These areas were assigned CN 70 and defined as water permeable. This value is chosen as appropriate for forests on soils of type C, in good condition; such a change involves the application of not only individual elements of green infrastructure, but a comprehensive approach. This value is taken as an average, the conditions of each specific site may differ depending on local factors, differences in the maintenance of green infrastructure, the scale of its implementation, etc.

For modeling, the runoff that would be formed from the volume of rain that fell in Kyiv on November 3, 2022, which is 17 mm, was chosen. Given the lack of data on its intensity in 10-minute increments and the purpose of the study, the distribution was carried out manually. Graph is presented on the Figure 3.

During the simulation, the main attention was paid to the maximum peak water flow. The results of the simulation of the passage of the flood at the mouth of the Lybid River are presented in Fig.4.

In the current conditions of formation of runoff, the peak of the flood is 33.84 $m^3.s^{-1}$. It occurs 2 hours after the passage of maximum precipitation (Fig. 3), while peak values exceeding 30 $m^3.s^{-1}$ last for about 50 minutes.

With the implementation of green infrastructure on an area that is slightly more than 5 % of the total, the peak of the flood is 30.78 $m^3.s^{-1}$, a difference is more than 9 %. At the same time, values exceeding 30 $m^3.s^{-1}$ last for 30 minutes against 50 in the first case.

It is worth noting that, according to the created model, the time of the peak of the flood basically does not change. The same applies to the overall duration of the rise-fall cycle of the flood. The impact of this rain event on the runoff ends at 8:40 p.m. under current conditions and at 8:50 p.m. with the increased area of green infrastructure, which is not a significant change. The average CN decreased from 86.68 to 85.52, the percentage of total impervious area fell from 21.36 % to 20.46 %, which is less than 1.5 %. Changes of a similar order are observed in the context of the time of the simulated flood, despite a rather significant difference in the volumes of water passing through.

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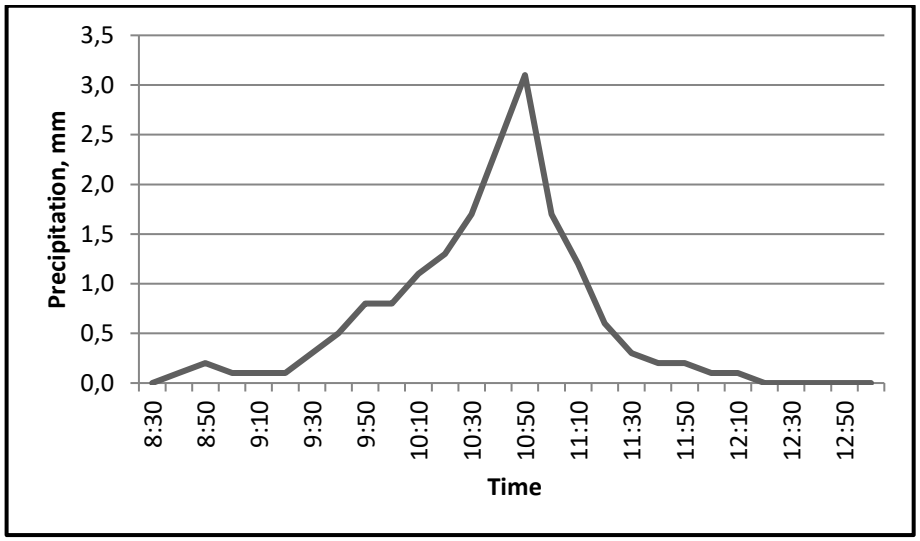

Figure 3 Rainfall intensity of the simulated scenario.

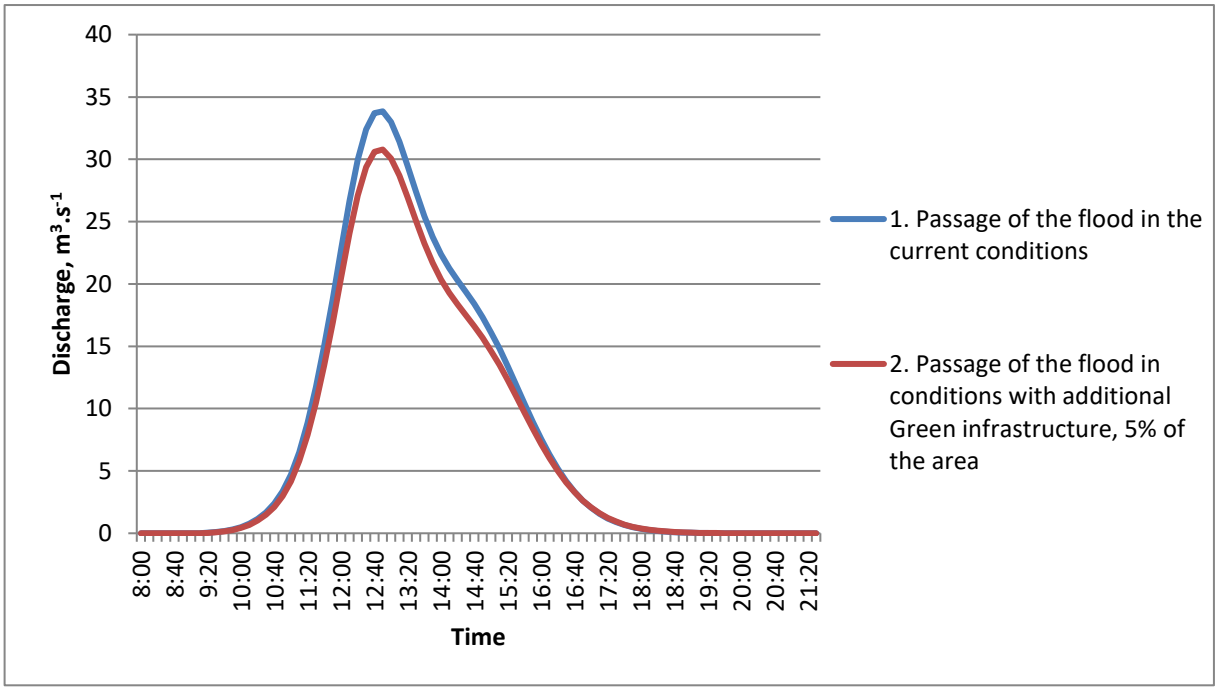

Figure 4 Flood simulation on the Lybid River, Kyiv

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4. Conclusions

In summary, it is worth noting the following things:

- Changing the surface cover through the installation of green infrastructure or complex reconstruction of districts with its application is a promising way to reduce the peak flow of flood water, in particular for the management of the small Lybid river basin.

- A change of 5.3% of the area leads to a reduction of the peak flow of the flood by 9%, which is a good indicator and can provide more stability to the structures located on the river and in the development of any projects related to the development of the river and its basin.

- It is necessary to develop a management plan for small rivers in the city of Kyiv, which will take into account the impact of land cover changes on river flow. And will consider the inclusion of green infrastructure there as a way to mitigate the risks caused by the urbanization of the territory and possible changes in the patterns of the passage of rain.

- In the presence of reliable data, the use of the SCS-CN method is promising due to the fact that it allows you to make approximate calculations quite quickly. It is a particularly useful tool considering the lack of such researches in Ukraine now. However, in urban conditions, SCS-CN application is limited, as well as limited possibilities for evaluating different scenarios of land cover change. At least with a change of only 5% of the area, other methods should probably be used to estimate the change in flood passage. Further simulations with a concentrated distribution of the proposed green infrastructure sites, rather than a uniform, as done in this case, is going to be carried out for verification.

This model needs calibration using measured data, and in the future, land cover classification will be refined for greater reliability.

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CSR AND SUSTAINABILITY IN THE CONTEXT OF AGRIFOOD INDUSTRY

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Abstract

In recent years, many companies have introduced environmental and social sustainability into their business mission and adopted corporate social responsibility (CSR) as a new business model tool. CSR and sustainability can also be observed in the growing attention of consumers, especially to ecological topics, as well as in the economic ethics of agrifood companies. The aim of this work is to provide another perspective on this relationship with a connection to the agri-food sector in Slovakia. Three hypothesis were set to reach the given aim. The research was based on a questionnaire survey with 726 parcitipating respondents from age generations X, Y and Z. We used various statistical methos for evaluating the obtained data. From a theoretical point of view, sustainability becomes a strong corporate value and a commitment to the future to protect the environment by limiting and using resources, as well as reducing the impact of products and processes on the environment. At the threshold of the 3rd millennium, CSR and sutainability are also connected with rationality and irrationality in creating preferences in consumer shopping behaviour.

Keywords: Corporate social responsibility; perception; rational and irrational consumer behavior; agrifood industry; sustainability

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1. Introduction

Corporate Social Responsibility (CSR) is becoming a key topic in the food chain, in fact it has become a widespread topic along with sustainable consumption. Changes in citizens' values, lifestyles, and preferences—as well as a new business culture that considers the environmental and social impacts of productive activity (Amaeshi et al. 2008)—have increased interest in the agricultural economics field towards the concept of corporate social responsibility (CSR). The world is facing a tough sustainability challenge that affects many areas, including the entire agri-food industry (Romei, 2018). Currently, the food system at the global level appears insufficient to meet people's needs and to ensure the protection of natural resources and the environment. Various health and social problems pose serious life challenges, while increasing food industrialization and globalization are destroying the environment and natural resources (Rawlinson and Ward, 2015). Tools to support sustainable food systems range from strict state regulation to weak state interventions based on market instruments to private voluntary initiatives. Private initiatives include a wide range of activities undertaken by firms according to their interpretation of corporate social responsibility (CSR) (Maloni and Brown, 2006).

The literature has primarily examined CSR from the consumer's perspective, noting that CSR creates added value by influencing consumers' rational perceptions of companies and products while increasing their loyalty and satisfaction (Luhmann and Theuvsen, 2016). Therefore, companies can use CSR as a differentiation strategy to attract and identify their customers, improve their corporate image and reputation, and their business performance (Brown and Dacin, 1997; Martos-Pedrero et al., 2019). This leads to a higher willingness to pay for the products of socially responsible companies (Mladenović et al. 2016). CSR positively affects innovation strategies because it forces companies to constantly improve the quality of their products and introduce sustainable processes aimed at innovation and environmental protection. Therefore, CSR strengthens the reputation of companies, which brings benefits for their image and identity, as well as for consumer recognition of the company's brand and products (Milić, 2021). Consumers

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need to make conscious and rational decisions about the impact and consumption of the products they buy on the environment and communities, and they need to change their habits with small everyday gestures, such as changing their shopping basket and favoring goods that have a low impact (Marcocci, 2021).

In order for CSR to effectively contribute to sustainability, it is important that a target perspective is promoted that emphasizes the contribution of agribusinesses to general interest goals such as environmental sustainability. CSR and the term sustainability are often used in meanings for marketing and advertising purposes and are superficially associated with nature, neglecting its dimensions in its entirety. In other words, CSR needs to be defined positively, i.e. consider what the business can do (Hingley, 2010). In addition, some form of monitoring of companies' actual behavior and achievement of CSR and sustainability goals is needed (Romei, 2018). The CSR activities of agrifood companies overlap and intertwine with more general issues of sustainable development: companies that carry out CSR activities are involved in the global model of sustainable development, where sustainability includes economic, social and environmental aspects, according to the so-called triple bottom line (Elkington, 2004, Coppola et al. 2020) with three pillars: economic, social and environmental responsibility and emphasizing that these three pillars are interconnected (Romei, 2018).

In the case of the CSR environmental pillar of agri-food companies, the concept of Corporate environmental responsibility can also be mentioned. Corporate environmental responsibility can be defined as the obligation to eliminate the environmental consequences of the company's operations, products and facilities; eliminate waste and emissions; maximize the efficiency and productivity of its resources; and minimize practices that could adversely affect the use of the country's resources by future generations (Mazurkiewicz, 2004). Corporate environmental responsibility refers to the active reduction of environmentally adverse business behavior and participation in environmentally beneficial activities in its daily business activities (Zeng et al. 2019). These benefits have ensured that in recent decades the concept of CSR has spread to all

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parts of the economy, including the agri-food sector (Stohl et al. 2007). The sustainability of the food supply chain has been suggested as one of the key factors that must be taken into account in the social measures implemented in this sector (Stohl et al., 2007). For this reason, most CSR/agri-food sector studies have focused on opportunities and challenges related to the sustainability of food supply systems (Hingley, 2010; Poetz et al., 2013).

The agri-food sector plays an important role in achieving many of the environmental and social goals that are part of the CRS concept. In terms of the environment, food production and distribution activities have significant adverse impacts in terms of pollutant emissions, depletion of non-renewable natural resources and contribution to climate change. In terms of social issues, the agri-food sector is even more important because it is necessary to guarantee the respect of basic human rights, such as the right to adequate food in terms of nutritional content (food security) and without health risks. Agri-food companies today operate in a complex and transnational context, which can lead to long and uncontrollable supply chains. The food system needs to undergo a revolution as soon as possible that will change the way food is produced, who produces it, where it is processed and distributed, how it is cooked and where it is eaten, that means it is time for all foods, companies, chains and networks to move towards more responsible business practices and better contribute to sustainable development (Romei, 2018).

Due to the constant market demand to ensure food quality and safety, the agri-food sector has seen rapid regulatory growth and new standards and guidelines have been introduced to support companies to develop their socially responsible strategies. Many agri-food companies are not willing to provide resources to implement corporate social responsibility (CSR) (Hartmann, 2011; Story and Neves, 2015). On the other hand, CSR can be seen as a form of investment through which agri-food companies can develop strategies that incorporate CSR attributes into their products or use CSR-related resources (McWilliams and Siegel, 2001), thereby minimizing the negative impact of crises. Therefore, if a company in any industry applies CSR activities, consumers will perceive it as reputation (Martos-Pedrero et al. 2019) quality and trust (Brown and Dacin, 2006). In addition,

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sustainability also becomes a commitment to the community through economic activity that is able to at least partially give back to the community and the country what it has received from them. In practice, this means that a business must design a business capable of renewal and long-term sustainability: operate with the resources (financial and environmental) actually available and behave responsibly towards all its stakeholders (consumers/customers, employees), territories in which the company operates) with regard to the environment, safety, social and cultural cohesion). It requires the ability to promote transparency and introspection in a company that is increasingly introspective, realizing that innovation, a good reputation and a good level of sustainability are essential conditions for becoming a company capable of lasting benefits (Romei, 2018).

Nowadays, environmental awareness appears as a universal European value that influences and guides European business practices, strategies and policies (Mihajlović et al., 2016). The policy of sustainable development is increasingly finding a place in the economies of developed countries (Popović, 2009), which leads to an increase in the importance of CSR as a tool (Milić, 2021). Within the European Union, concerns regarding sustainable development and CSR are very intense, and specific strategies and normative standards are being created to encourage companies to launch various CSR programs, but also to disclose non-financial information so that stakeholders can base their economic decisions on correct data. CSR is therefore the right tool for building a socially and environmentally sustainable future. Issues of the sustainability of the agri-food sector and CSR activities are specific in the context of the challenges that the transition to the bioeconomy also brings (Zaman et al. 2020). For all companies that operate in the food sector, the environmental dimension is of fundamental importance.Impact of agriculture on multiple components: air, soil, water, biodiversity and landscape (Marcocci, 2021).

The promotion of sustainability in the agri-food system is driven by both endogenous factors, such as the commitment of individual companies, and exogenous factors, such as consumer demand, which is increasingly focused on the issue of sustainability, CSR and national and international regulations, such as European agreement (Marcocci, 2021).

 DOI: https://doi.org/10.15414/2023.9788055226217

Especially within the framework of the Green Agreement, an important part is reserved for the "From farm to table" strategy, the aim of which is to promote a significant transformation of the European agri-food system, i.e. also in the territory of Slovakia. It is a ten-year plan that proposes measures and targets throughout the food chain, from production to consumption. The bottom line is to make food systems more sustainable. It contains the main sustainability goals of the agri-food sector:

- ⇒ Guarantee sustainable food production;
- ⇒ Ensure food safety;
- ⇒ Support a sustainable food chain from processing to sale, including additional services;
- ⇒ Support the consumption of sustainable food and the transition to a healthy diet
- ⇒ customs;
- ⇒ Reduce food waste;
- ⇒ Combating food fraud in the supply chain (European Comission, 2020).

The agri-food system is at the center of current and future challenges for a more sustainable world.Many world institutions and organizations, such as FAO (Food and Agriculture Organization of United Nations), IFAD (International Fund for Agricultural Development) and WHO (World Helath Organization), are committed to responding to the challenges of a sustainable world. In 2015, the member states of the United Nations presented the 2030 Agenda for Sustainable Development (Fig. 1), a program is divided into 17 Sustainable Development Goals, the basic principles of which are the end of poverty, hunger and malnutrition, sustainable development in agriculture, fisheries and forestry, and response to change climate. In particular, FAO identifies 5 main challenges that will involve the sector in the coming decades:

- ⇒ Provide food and other products sufficient to meet growing and changing global needs;
- ⇒ Eliminate hunger and food insecurity;

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⇒ Preserve and improve productivity and sustainable use of available natural resources

⇒ Adapt to climate change;

⇒ Contribute to mitigating climate change (Marocci, 2021).

Figure 1 Sustainable developement goals (Source: European Comission, 2020)

2. Materials and methods

The submitted paper investigates the awareness of CSR and sustainability in the context of agrifood industry in Slovakia. In the paper also includes principles of consumer behaviour and influence of rationality and irrationality in creating preferences in consumer behaviour based on CSR and sustainability of agrifood companies. In order to analyze the corporate social responsibility and sustainability in the context of agrifood industry in Slovakia, the study was condtucted. The research was based on the application of data collection from primary sources. First, the most important issues related to the topic were explored and transferred to the questionnaire offered to the online respondents. We ensured the representativeness of the research sample by addressing the questionnaire to target interest groups, including respondents of all age categories, which were divided in to the age generations - X,Y and Z. The results of a questionnaire survey with 726 participating respondents, 401 women and 325 men showed that although they are familiar

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with the concept of CSR and sustainability, a large percentage of respondents need to learn about these activities or pay more attention to them.

The main goal of the research was to determine the CSR activities and sustainable approaches in agrifood companies and its influence on consumer behavior. In the presented research, we assumed that the results would provide as various answers about the given topic. We were interested, whether respondents are aware of the concept of CSR and sustainability in the concept of agrigood companies. We were also interested in whether the respondents are aware of the importance of these activities and approaches, not only for increasing the company's reputation, but also for environmental protection and reducing the impact of various harmful effects on the environment, whether from the point of view of food production or consumption. We were also interested in whether these activities and sustainable approaches of companies can influence consumer behavior to a certain extent, whether from the point of view of the consumer's willingness to purchase a sustainable or socially responsible product, or whether they can influence consumer behavior in general and lead them to more responsible purchasing behavior and consumption. Three hypotheses were set to for the analysis CSR and sustainability in the context of agrifood industry and its influence on consumer behaviour. To meet the goal of this paper, we will use selected statistical methods such as Chi-square test , Pearson Chi-square test and Test of proportion agreement with a known constant.

2.1 Pearson's Chi-square test

Pearson’s Chi-square test (1) is used to verify whether a random variable has a predetermined probability distribution. Pearson's chi-square test is a statistical test for categorical data. The chi-square test compares two variables in a contingency table.

$$X^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \quad (1)$$

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Where:

- X^2 -the chi-square test statistic
- Σ - the summation operator (it means “take the sum of”)
- Oi - the observed frequency
- *E* – the expected frequency.

2.2 Test of proportion agreement with a known constant

We assume that the proportion π is equal to the known constant π0. If the proportion is equal to a known constant, we accept the null hypothesis. If it happens that the proportion is not equal to a known constant, we reject the null hypothesis and accept the alternative hypothesis. Matejková et al. (2015) states that we calculate relation (2):

$$u = \frac{p - \pi_0}{\sigma_p} \quad \sigma_p = \sqrt{\frac{\pi(1-\pi)}{n-1}} \qquad (2)$$

Where:

- u– N (0,1) rozdelenie
- $|u| < u_{1-a/2} \rightarrow H_0$ rejection
- $|u| \geq u_{1-a/2} \rightarrow H_0$ acceptation

2.3 Chi-square test

Representativeness of the selected sample of respondents who took part in the questionnaire survey, we verified by using the Chi-square statistical method. We established the following statistical hypotheses.

H0: *The sample set is representative from a point of view.*

H1: *The sample set is not representative from a point of view.*

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Matejková et. al (2015) it is stated that for the correct Chi-square test it is necessary to use the calculation of the formula (3):

$$\chi^2 = \sum_{i=1}^{k} \frac{(E_i - T_i)^2}{T_i} \quad (3)$$

Where:

- x^2 – calculated test criterion
- E_i – empirical frequencies
- T_i – theoretical frequencies

3. Results and discussion

Based on the Chi-square goodness-of-fit test, we verified whether the sample set was representative in terms of gender. We insert the theoretical and empirical frequencies into the formula. We calculated the value of the test criterion, which was 0.42 (Table 1).

Table 1

Gender	Population	Sample	**T**	**(E-T) ^2/T**
Women	1514000	401	1514401	0.19
Men	1288000	325	1288325	0.23
Total	2802000	726	28002000	*0.42*

Source: Own elabortation

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In Excel, we calculated the critical value using the CHIINV function. We used a significance level of 0.05 and a degree of freedom of 1. This value was 0.42. We then compared the test criterion and the critical value. After comparing these values, we found that the test criterion is less than the critical value. This means that we have accepted the null hypothesis and rejected the alternative hypothesis. The null hypothesis states that the sample is representative in terms of gender.

3.1 Hypothesis

H1: *We assume that more than 25% of respondents would be willing to pay a higher price for a socially responsible product.*

H2: *We assume that more than 30% perceive the CSR activities of agrifood companies as trustworthy*

H3: *We assume that generation Z pays more attention to eliminating food waste than generation Y*

3.1.1 Willingness to pay for socially responsible product

H1: *We assume that more than 25% of respondents would be willing to pay a higher price for a socially responsible product*

The first hypothesis, which we will statistically evaluate, focuses on the respondents'willingness to pay more for socially responsible product. The figure 2 below shows the respondents' answers. Of 726 respondents, 210 respondents are considered as not willing to pay more for the socially responsible product. This represents 29% of respondents. 516 respondents which represents 71%, are willing to pay more for socially responsible products.

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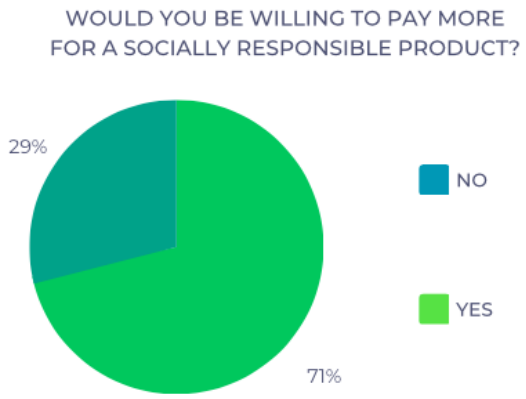

Figure 2 Respondents' willingness to pay more for a socially responsible product (Source: Own elabortation)

To evaluate the statistical dependence, we used the test of proportion agreement with a known constant. We established the null and alternative hypothesis. The P value of the test of the proportion with a known constant (0.25 or 25 %) is 0.0408 and therefore we reject the null hypothesis at the significance level of 0.05. The share of people who chose the helpline is higher than 25 %.

3.1.2. Perception CSR activities of agrifood companies

H1: *We assume that more than 30% respondents perceive the CSR activities of agrifood companies as trustworthy.*

The second hypothesis focuses on whether respondents perceive the CSR activities of agrifood companies as trustworthy. The figure 3 below shows the respondents' answers. 545 of respondents do not perceive CSR activities of agrifood companies as trustworthy, on the other hand out of 726 total respondents, 181 respondents perceive CSR activities of agrifood companies as trustworthy. This means, that these 181 respondets do not perceive CSR activities only as a marketing tool of agrifood companies.

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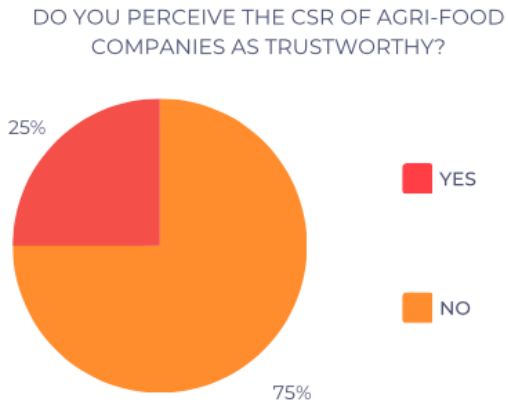

Figure 3 Perception of CSR activities of agrifood companies (Source: Own elabortation)

The figure 3 shows that the number of respondents who perceive CSR activities as trustworthy is exactly 25 %. In order to statistically verify the hypothesis, we used the Test of proportion agreement with a known constant, where the constant represents 30 %. The P value of the test is 0.86 %, so we cannot reject the null hypothesis. The share of respondents who perceive the CSR activities of agrifood companies as trustworthy is not higher than 30 %.

3.1.3 Elimination of food waste

H3: *We assume that generation Z pays more attention to eliminating food waste than generation Y.*

The total number of respondents born in the years 1966-1976, 43.8% ensure that they do not create food waste when consuming food and foodstuffs. In the case of Generation Z, from the number of 232 respondents born in the years 1995-2010, 70.9% ensure not to create any food waste when eating and consuming food. Approximately 29.1% of the respondents of the selected age category do not pay attention to the prevention and elimination of food waste. In fact, more

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than half of respondents from generation Y also try to minimize the creation of food waste when eating and consuming food.

We verified the hypothesis using the Chi-square test of independence. The P value of the test is less than the chosen significance level of 0.05 and therefore we do not reject the null hypothesis. To determine the differences, we used the so-called Corrected residuals in SPSS (Table 2). Values outside the +-1.96 range are considered significant. The corrected residual for the answer yes is 4.7 and this percentage is statistically significantly different from the percentage assumed in the null hypothesis. Generation Z cares more about prevention and the creation of food waste than generations Y and X.

Table 2 Chi-Square test

	Value	*df*	*Asymptotic Significance (2-sided)*	*Exact Sig. (2-sided)*
Pearson Chi-Square	27.422[a]	2	.000	.000
N of Valid Cases	671			

Source: Authors'calculations

4. Conclusion

This paper illustrates a conceptual framework of the relationship between CSR and sustainability in the agrifood industry in Slovakia.Sustainable development and the reduction of the negative effects of the company's actions on the environment are frequently discussed topics recently. Companies and individuals are beginning to realize that it is necessary to take certain measures and adapt their behavior in order to avoid the complete devastation of the environment and the depletion of resources. Corporate social responsibility has been shown to be a fundamental element in the formation of agrifood companies' reputations, in that it makes consumers perceive that their food products comply with food safety and health standards which, in turn, creates higher-quality images than companies that do not carry out social actions. Based on the chosen

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issue, we conducted a questionnaire survey focused on CSR activities and sustainability in the context of agrifood industry in Slovakia. Any other researcher in Slovakia still needs to carry out research with such a focus. The questionnaire survey with 726 participating respondents showed that, eventhough the respondents are aware of CSR activities of companies and they understand the importance of applying sustainable approaches, they need to pay more attention to them and so do agrifood companies. These activities need to by carried more by agrifood companies. Based on the results of presented research, respondents consider it important not to waste food and food and not to create and eliminate food waste. Also, on the basis of the completed questionnaire, we can say that the respondents are aware of the fact that it is important for companies to establish the principles of sustainability and apply the principles of socially responsible business, whether within the social, economic or environmental pillar. On the other hand, it is important that consumers also change their view on their approach to life, and realize how important it is to apply sustainability in everyday life. In addition, this research provides very important information for agrifood companies about the influence of CSR actions on consumer behaviour, what implications these actions have for company managements and how they can be translated into positive financial impacts and better corporate images. When consumers perceive that a product is of high quality, this creates greater satisfaction and in turn, loyalty towards companies that carry out CSR actions and to their products.

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THE USE OF PHYTOCHEMICALS IN THE PREVENTION AND TREATMENT OF HUMAN DISEASES

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Abstract

Phytochemicals play an important role in diseases such as diabetes, atherosclerosis, obesity, osteoporosis, cardiovascular disease, and others. Evidence from various studies clearly shows a positive relationship between various phytochemicals. Whole plant products are significant in terms of their effect, mainly because of the complexity of the bioactive compounds and their synergistic action, which is not achieved when specific bioactive compounds are taken individually. We investigated the effect of a modified Restricted Diet on the reduction of disease risk and improvement of current health status in 10 selected adolescent volunteers. Volunteers with arthritis, digestive disorders, elevated cholesterol, migraine, type 2 diabetes, hypertension, and obesity were selected for the 7-day Restricted Diet. In the study, we compared the biochemical parameters of probands with BMI exceeding the norm before and after starting the restrictive diet. We recorded their feelings and physiological changes during and after the diet. The proposed diet was consistent with the hypothesis we had established, which predicted a positive change in the current health status of the participating volunteer probands. The phytochemicals contained in the plant foods contributed to the effect of modifying the health status of the volunteer probands, for all specific health problems.

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Keywords: phytochemicals, pharmaceuticals, plant products, diseases.

1. Introduction

A Restrictive diet, which consists of plant-based types of food, helps to remove from the body toxic substances and various harmful metabolites in a natural way, and this is the first step towards healing an individual. We are currently living in an era of chronic diseases, and if a person wants to prevent them, he must change his lifestyle, that is, change his eating habits and increase physical activity. The most common chronic diseases are cardiovascular disease, cancer, diabetes mellitus, etc. By definition, the WHO definition of health is "a state of complete social, mental and physical well-being, not merely the absence of disease'. It is a dynamic process, i.e. health is not a permanent and unchanging state. Influences it is influenced by both external and internal factors. One of the external influences on health is, for example, the diet of an individual. Nutrition is an integral part of the life of every living being. Among the most important principles of a healthy diet is the intake of a varied, high-quality, and balanced diet. Vegetables and fruit have an irreplaceable place in the human diet due to their high content of vitamins, minerals, fiber, bioactive substances, and other important components that have a beneficial effect on physiological processes in our organisms (Cena, Calder, 2020). With the help of soluble fiber, toxic substances such as lead and mercury are eliminated from the body, and cholesterol, bile acids, and others stabilize blood sugar fluctuations, bind fats and cholesterol, and satiate and stimulate bowel movements (Lattimer, Haub, 2010). One of the current trends in healthy eating is the intake of fruit and vegetables because of the bioactive substances that have a beneficial effect on the human organism. Bioactive substances include a large group of flavonoids, which have anti-cancer effects, and protect against cardiovascular diseases, but also high blood pressure (Jedlička, 2012). According to the new recommendations, fruit and vegetable consumption should be at least 400 g per day, i.e. it should be part of every daily meal (Pem and Jeewon, 2015). Fresh fruit and vegetable juices, vegetable broths, and salads are a means of cleansing the body in the form of restrictive diets. Today, however, not only the state and the doctor but above all the citizens themselves must be

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responsible for their health, for prevention, and for their share of maintaining good health. Taking care of healthy nutrition is taking care of oneself, not restricting oneself.

2. Material and Methods

The aim of our experiment, which lasted 7 days, was to demonstrate the positive effect of a restrictive diet on probands, improving their biochemical parameters and their general health. The restrictive diet was based on the consumption of fruit, vegetable juices, potatoes, and rice as well as a short (36 hours) fasting period to cleanse the body. Researched the effect of phytochemicals and other substances found in different fruits, vegetables, herbs, red wine, and others, on reducing the risk of diseases: hypercholesterolemia, obesity, diabetes, and hypertension (Jedlička, J. 2014).

2.1 Probands file

9 people with different health problems participated in the research, 6 of them were women and 3 men. Their ages ranged from 31 to 66 years.

2.1.1 Duration of the experiment

The experiment we conducted lasted for 7 days, after the detox diet, we were in contact with the probands if this diet was not sufficient for a complete recovery. After the end of the experiment, constant contact with probands and follow-up longitudinal follow-up of their health status, especially those probands for whom the duration of the detoxification diet was not sufficient for "complete" recovery, return to optimal physiological values.

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Table 1 Initial diagnosis of probands

Proband	Age	Weight (kg)	Height (cm)	Profession, activity	Health problems	BMI
1. female	43	69,5	172	teacher, trainer, regularly plays sports (running, weight training).	high cholesterol, problems with water retention	23,3 normal weight
2. female	66	108	180	teacher, veterinary doctor In her youth she played sports, now she cycles, and hikes	swelling of the lower limbs (mainly in the evening), migraine, type 2 diabetes mellitus	33.3 First obesity band, Intermediate obesity
3. female	31	55	165	housewife, regularly swims	low pressure, she gets dizzy, digestive problems (bloating), hemorrhoids	20,2 normal weight
4. female	52	65	169	saleswoman, works out at home and goes to the gym. she also goes for long walks.	lupus, joint pain	22,76 normal weight
5. male	35	80,6	178	computer scientist, used to play football, now works out, cycles, and skis	tense body, problem with falling asleep, bloated abdomen in the stomach area	22,4 normal weight
6. female	29	48	156	kindergarten teacher, seasonal sports	messed up hormones, menstrual problems, acne in the back and face	19,72 normal weight
7. male	42	98	180	fitness trainer, strength trainer	joint pain, knee pain	30.25 Grade 1 obesity (due to weight training and high % muscle mass, this proband's BMI score is skewed)
8. female	56	76	168	teacher, veterinarian, hiking, cycling and seasonal sports	migraine, knee pain, high cholesterol	26,93 Overweight
9. male	40	105	185	doctor of medicine, fitness, hiking,	higher cholesterol, high blood pressure	30,6 First obesity band Intermediate obesity

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Foodstuffs used and their modification. Potatoes boiled in the skin, rice natural. Vegetable juices: carrots (always about 2/3 of the juice volume), parsley, black radish, beetroot, cabbage, broccoli, celery, chicory (endive), herbal tincture (liquid extract of herbs). Fruit juices from fruits: apples, pears, lemons, grapefruits. Vegetable broth: a mixture of vegetables. Herbs as ingredients: seasoning of potatoes and rice (herbal seasonings (aniseed, basil, kitchen garlic, garden marjoram, peppermint, nutmeg, oregano, rosemary, sage, saffron, thyme). For two days before arrival, probands ate only light, meatless meals!

2.2 Regimen measures during the 7 days of the restrictive diet

Day 1 - 3 - reduction of food energy intake to prepare the body for fasting, 4th - 5th day until noon - fasting (36 hours), day 5 from 12.30 p.m. - increasing food energy intake to return to normal eating, as on day the 3 from lunch onwards, day 6 as on day 2 and day 7 is on day 1 until 6 p.m.

2.3 Drinking regime

The drinking regimen was applied individually by probands according to their needs, with a choice of tap water or unsweetened green tea (except during the fasting period, when they drank only water tap water).

2.4 Physical activity

Physical activity: walk in the field for 1 and ½ hours every morning and afternoon. The probands completed walks even during the hunger strike

2.5 Changes in the state of the organism

Changes in body condition during the restrictive diet, a 36-hour fasting period, and immediately after the end of the experiment were measured: changes in blood pressure: with a Beurer BM 65 blood pressure monitor, changes in weight: personal scale, changes in cholesterol levels:

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biochemical blood tests, BMI (body mass index): by calculation - weight/height (in m^2), changes in the subjective expression of pain: based on the probands' feelings.

2.5.1 Accompanying activities

We will be in constant contact with the enrolled probands, and we will consult with them about anybody changes observed during and after the completion of the 7-day modified diet. Recording of subjective sensations and changes in the body. Subjects kept a daily written record of all ongoing cognitive and somatic changes in their body, which we collectively assessed daily.

2.5.2 Methods of statistical evaluation of Results

Statgraphycs.

3. Results and discussion

Table 2 Reference values from blood pressure (mm Hg) before and after the diet

1. proband	110/70	117/80
2. proband	135/91	130/86
3. proband	77/58	100/60
4. proband	122/84	120/80
5. proband	121/80	117/80
6. proband	90/70	100/75
7. proband	125/90	120/80
8. proband	120/80	120/80
9. proband	132/86	125/78

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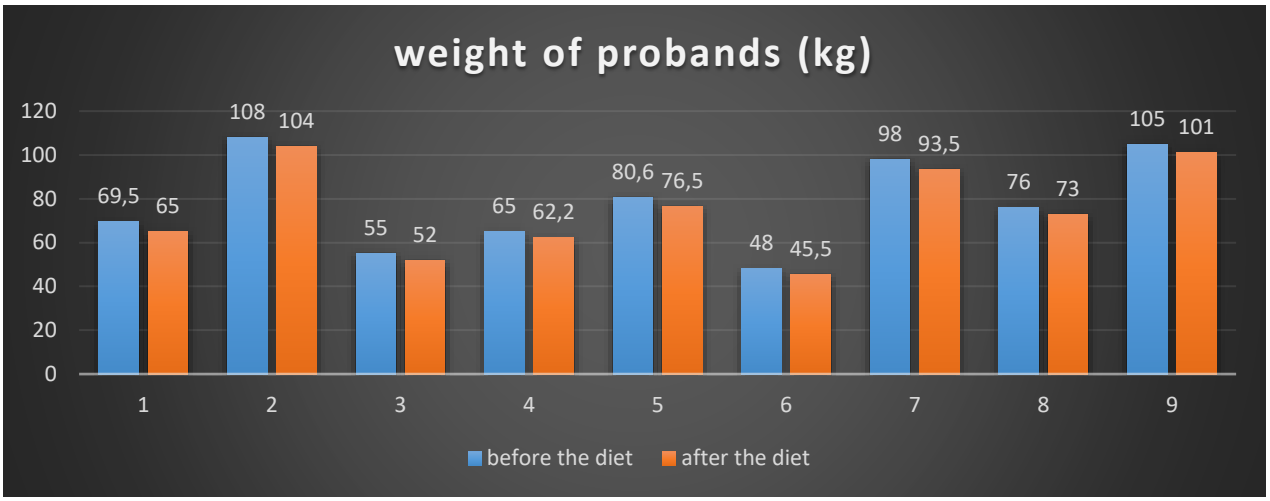

Figure 1 Weight before and after a restrictive diet

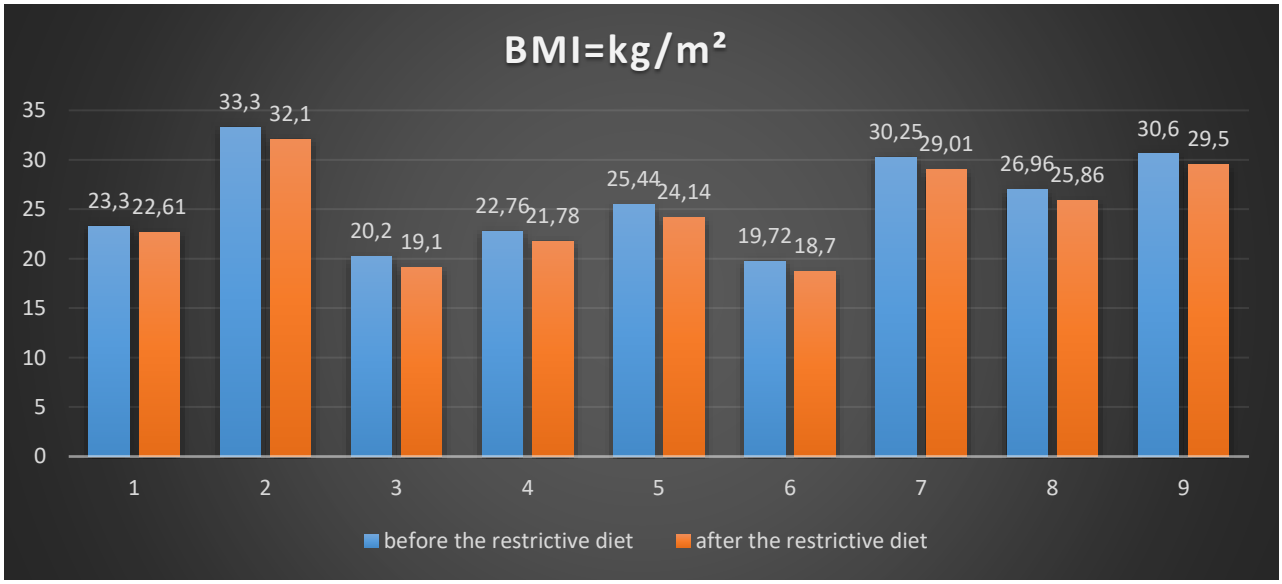

Figure 2 BMI - The BMI calculation divides an adult's weight in kilograms (kg) by their height in meters (m) squared.

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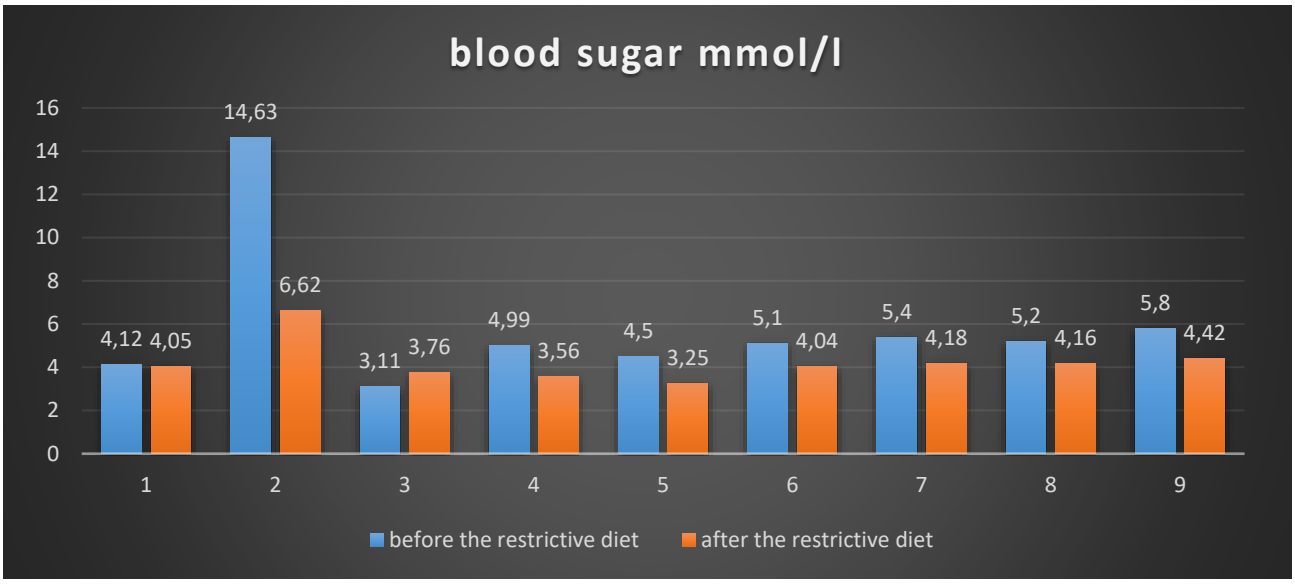

Figure 3 Blood sugar

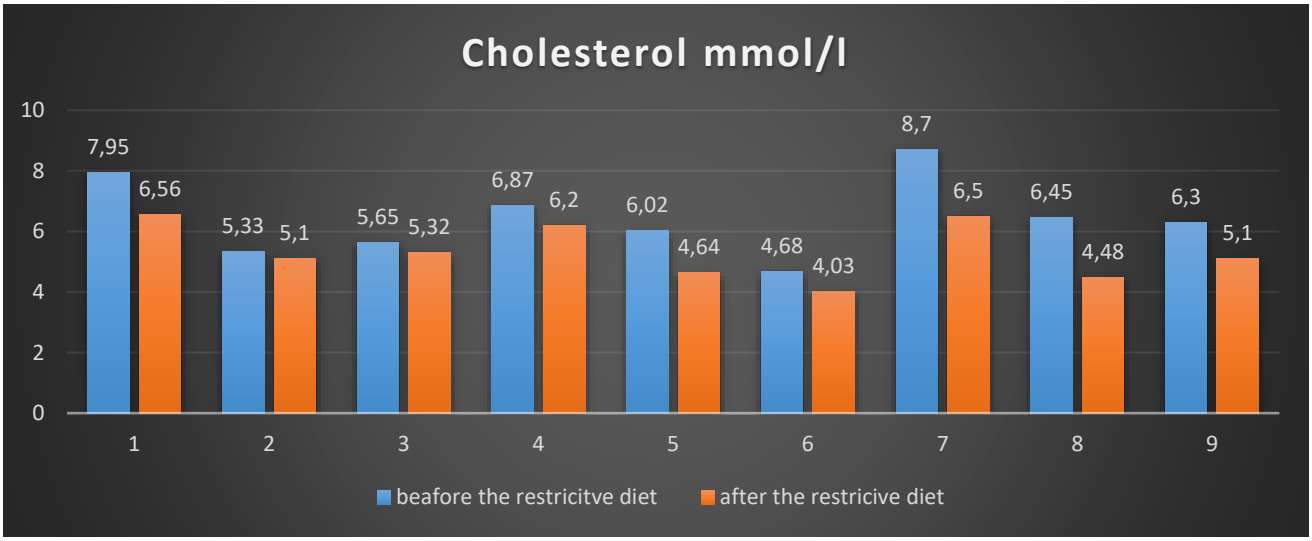

Figure 4 Cholesterol

Participants were worried that they would not be able to participate in the experiment because they could not handle it. They participated in a restrictive diet because of their recurrent health problems and also their goal was to lose weight.

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As you can see in the tables and graphs before and after the diet, we monitored changes in blood pressure, cholesterol, blood sugar, weight, and BMI. All values were better after the diet with minimal fat intake. Proband number 2 had the largest difference between baseline and baseline tests. Her blood sugar dropped from 14.63 mmol/l to 6.62 mmol/l. Proband number 7 also had a significant drop in her cholesterol value from 8.7 mmol/l to 6.5 mmol/l. All of our participants lost an average of 4.75 kg during the restrictive diet, which was also reflected in the subsequent BMI value. All of them reported better fitness.

Subjective feelings during the experiment: on the first day, participants experienced nervousness, hunger, and dizziness and also had mild headaches. Due to the fasting on the fourth day, participants felt more energy. All values were better after a diet with minimal fat intake. Finally, their mental and physical health improved.

Similar studies also point to the positive impact of a restrictive diet high in phytochemicals. The research Jedlička (2012) reports that probands had headaches, diarrhea, insomnia, and joint pain during the restrictive diet which spontaneously disappeared after a few hours. The organism, by mobilizing its self-healing mechanisms, coped with the problems. The positive effect of fruit and vegetable consumption, in various forms of preparation, on reducing the risk of diabetes mellitus has been confirmed by authors such as Hamer and Chida, (2007); Bazzano et al., (2008); Liu et al. (2004); Ford and Mokdad, (2001); and Williams at al., (1999). According to Wang (2012), a high intake of fruits and vegetables is statistically significant in preventing hypertension and improving weight management.

The effect of a restrictive diet on the healing processes of the body has been addressed by several authors such as Diškanová, (2021)., Žideková, (2015)., Tóthová, (2022), Matlochová, (2016) and others. All of them report in their research the improvement of biochemical values and the overall positive effect on the health of probands.

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The plant-based diet is high in fiber, so it helps to reduce weight, cholesterol levels, and satiety. Participants took part in our restrictive diet experiment because of recurrent health problems and also their goal was to lose weight. Participants were concerned that they would not be able to participate in this experiment. On the first day, participants experienced nervousness, hunger, and dizziness and also had mild headaches. Due to fasting on the fourth day, participants felt more energy. Eventually, their mental and physical health improved. Nutrition experts also point out the importance of fruit and vegetable intake.

Due to high water content and low-fat content plant-based foods have low caloric intake. Phytochemicals are natural bioactive compounds that have great antioxidant potential, anti-inflammatory, antimicrobial, antidiabetic, antiaging, antiparasitic, anticancer, antidepressant, and wound healing (Sudheer, S., et al. 2022). Many organizations believe that low consumption of vegetables and fruits is the main public health problem. People with poor lifestyles and bad eating habits are at risk of cardiovascular disease. Low fruit and vegetable intake is the most important risk of mortality and risk of incidence or mortality. Every year 1,7 million of life's worldwide could be saved if vegetable and fruit intake would be adequate.

4. Conclusion

Before and after dieting, we monitored changes in blood pressure, cholesterol, blood sugar, weight, and BMI. All values were better after the diet with minimal fat intake.

The plant-based diet is high in fiber so it helps to reduce weight, cholesterol, and satiety. Participants took part in our restrictive diet experiment because of recurrent health problems and also their goal was to lose weight. Participants were concerned that they would not be able to participate in this experiment. All of our probands lost an average of 4.75 kg during the restrictive diet, which was also a low-calorie diet, which they said was reflected in their physical comfort and fitness.

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Plant-based foods are characterized by their low caloric value (due to their high water content and low-fat content). Phytochemicals are natural bioactive compounds that have great antioxidant potential, anti-inflammatory, antimicrobial, antidiabetic, anti-aging, anti-parasitic, anti-cancer, antidepressant, and wound healing effects.

Many organizations believe that low consumption of vegetables and fruit is a major public health problem. People with poor lifestyles and poor eating habits are at risk of cardiovascular disease. Low consumption of fruit and vegetables is one of the ten most important risk factors for mortality. According to the World Health Organisation, up to 1.7 million lives could be saved each year if fruit and vegetables were consumed in adequate quantities worldwide.

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POSTER SECTION

Mitigating effect of Urban Green Spaces on the Urban Heat Island in Zvolen, Slovakia

VEDA MLADÝCH - SCIENCE OF YOUTH 2023
DOI: https://doi.org/10.15414/2023.9788055226217
17th annual international scientific conference

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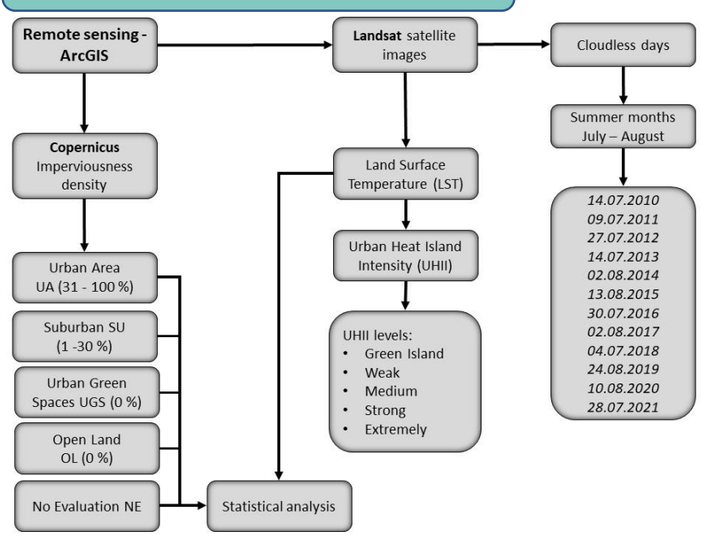
Introduction

Increasing temperatures, expanding cities and industrial areas contribute to the creation of an Urban Heat Island (UHI). Research has shown that cities are almost always warmer that their surroundings. UHI contributes to human discomfort, health problems and may worsen during heat waves. It can be mitigated by increasing UGS (Urban Green Spaces), which provides many benefits.

The aim of the study:

- to confirm the existence of UHI during summertime in a medium size town surrounded by agricultural and forested landscape
- to prove that urban greenery has an impact on mitigating the UHI

Materials and Methods:



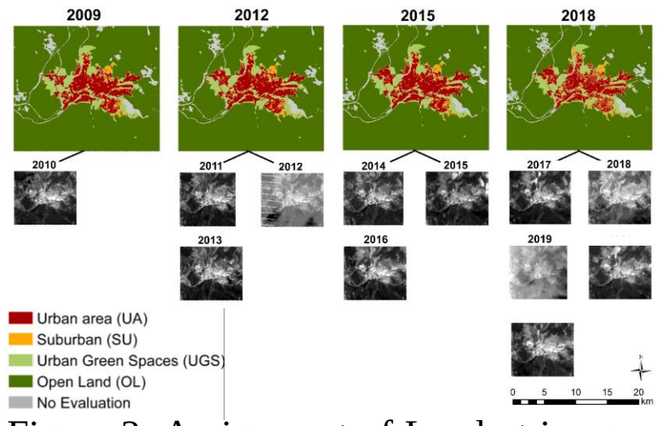


Figure 2: Assignment of Landsat images defined with Copernicus imperviousness density data

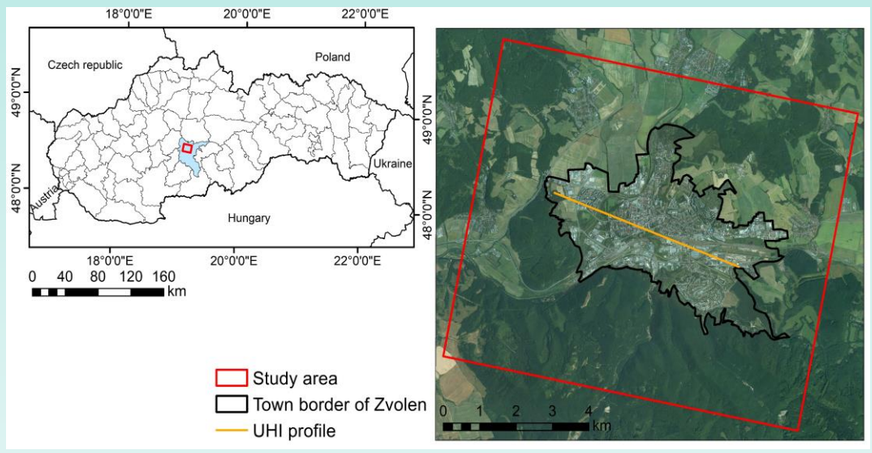


Figure 1: Location of the study area. Note: The town boundary separates the urban zones and the open land

Results:

The temperature difference depended on the town surface coverage, and compared to LST of the open land, we can arrange the evaluated parts of the town in descending order as follows:

- Urban Area was on average warmer by 5.6 °C (compared to Open Land)
- Suburban Area was on average 3.8 °C warmer (compared to Open Land)
- UGS were on average 2 °C warmer (compared to Open Land)
- UGS were on average – 3.5 °C colder (compared to Urban Area)
- UGS were on average – 1.6 °C colder (compared to Suburban Area)

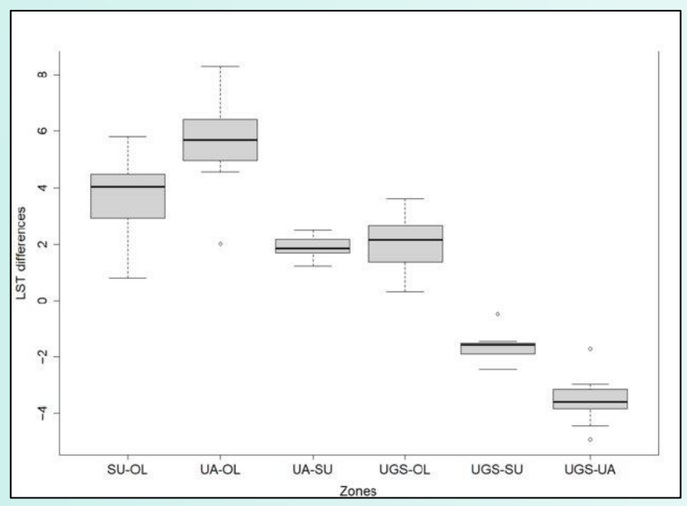


Figure 3: Comparison of average LST differences between pairs of zones for the entire evaluated period

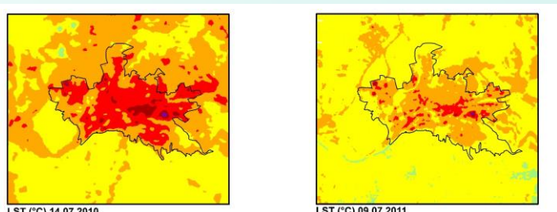


Figure 4: Calculated LST values for evaluated days between the years 2010–2021

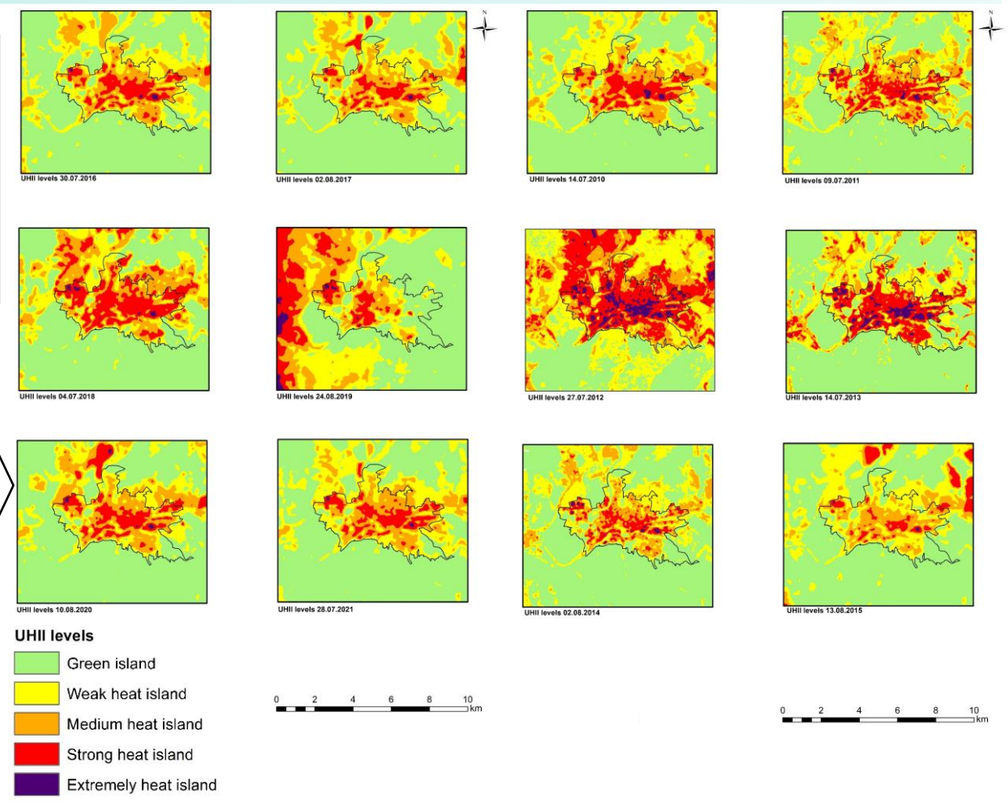


Figure 5: Urban Heat Island Intensity in the years 2010–2021

Conclusions:

The study confirmed the existence of the UHI effect during the summer months between 2010 and 2021, even in such a medium size town as Zvolen and UGS are significantly cooler during hot days. The warmer the weather, the higher the difference, while on a notably colder day, there was no significant difference between the zones.

Citation: Murtinová, V.; Gallay, I.; Olah, B. Mitigating Effect of Urban Green Spaces on Surface Urban Heat Island during Summer Period on an Example of a Medium Size Town of Zvolen, Slovakia. Remote Sens. 2022, 14, 4492. https://doi.org/10.3390/ rs14184492

Impact of substrate adsorption behavior for emerging pollutants in constructed wetlands

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Introduction

Emerging pollutants have attracted increasing concern due to the dramatic growth in population and rapid industrialization in the 20th century worldwide. Large-scale production and use of EPs as goods, services, personal care products, pharmaceuticals, and further discharge of their processed products into the environment are some of the crucial causes of ecosystem disturbance in the 21century. Moreover, water and air pollution greatly impact the human immune system. Consequently, they have an extremely negative effect on the whole body, such as increased morbidity and mortality and different kinds of allergies.

Sources of EPs are agricultural, urban, and rural areas. The emerging contaminants, including personal care products, are known as (PPCPs), Non-steroidal anti-inflammatory drugs (NSAIDs), hormones, pesticides, plasticizers, industrial and household products, metals, food additives, solvents, flame retardants, and other organic compounds in the water generated mainly by human activities (WWW.UNESCO.ORG, 2019). PPCPs such as detergent for the washing machine may anticipate ensuring daily human life in terms of comfort: time saver and alleviating manual labor. While on the other hand, their usage has environmental harm by polluting and dwindling the supply of resources and destructively altering the climate condition. Another significant negative contribution is that washing machines require high energy consumption from fossil fuels. Fossil fuels are burning for energy production, at the same time producing carbon dioxide and greenhouse gases. After the penetration into the air, they aggravate the global warming crisis. Furthermore, beyond the existing issues, the onset of the COVID-19 pandemic enhanced PPCPs production and medical consumables and caused an extremely high discharge of waste in the ecosystem. Hence, the consequences for the environment of releasing the debris, including non-biodegradable plastic syringes, pose additional challenges for ecologists.

Wastewater treatment plants (WWTPs) focus on removing contaminants from wastewater and, by effluent, discharge it into the water cycle. However, the most WWTPs were not designed to eliminate PPCPs, including NSAIDs. Therefore, in the world, especially in big cities, the overflow of the sewage system causes a significant content of EPs in the groundwater and surface water. So, the occurrence of EPs in the environment and their detection in different combinations are constantly reported and accounted for worldwide.

Once released into the environment, the degradation process begins. Unfortunately, the behavior of many EPs is still insufficiently understood. Therefore it can be out of control and cause or aggravate undesirable consequences. Therefore a rising interest over the last years in monitoring the presence and influence of EPs in the environment, mainly in surface water bodies.

Constructed wetlands have been proposed and successfully used as an ecologically friendly option for wastewater treatment during the last decades. These alternative systems have been tremendously productive in preventing ecological impact and low operating costs. Therefore, CWs have been identified as a sustainable wastewater management solution worldwide. The components of CWs included: substrates, emergent/submerged vegetation, and water.

Large-scale production and consumption load conventional WWTPs, which are not designed for many pollutants, including medicals, that appear in large amounts in the water. Additionally, the COVID-19 pandemic raised the release of a considerable amount of medicine in the sewage system. Thus, an urgent need arose to use CWs in terms of efficiency, economy, and ecologically friendly application. NSAIDs' removal method in CWs, including IBU and DCF and sorption efficiency of given absorbent, are still not thoroughly studied. Their further fate is still not well understood.

Therefore, the primary purpose of this research was:

-To investigate and compare the adsorption behavior of the chosen substrate: sand and perlite for selected EPs in VSSF CWs.

-To analyze and estimate their role and purification ability in CWs for removing EPs, including pharmaceuticals IBU and DCF.

Method and Experimental setup

The experimental section of the thesis is based on the small-scale experimental sub-surface vertical constructed wetlands.The CW's setup comprises innovative KG-system (PVC) pipes, substrates (sand, gravel, and perlite), wetland plants, and water outlets. The observed device consisted of 6 reactors grouped into two categories (A, B) to simulate the VSSF CWs.

According to the root characteristics, a common wetland plant species, G. maxima, were selected. Sand samples were collected, air-dried, and then sieved to a particle size < 2 mm. Each column of the physical models had an open top imitating a natural water bog. All the reactors had a sampling point as an orifice with a hose for the water running down, located 25 cm above the plastic bottom. Each of the six reactors has dimensions of 150 mm in width and 550 mm high and consists of a plastic base and column, which made watering (Figure 1). All six individual systems of CWs were carried out in the PVC materials column, divided into three layers: bottom layer, middle layer, and top layer for the type and number of substrate layers. Category A reactor contained gravel and sand-based substrate. The A method of the substrate consisted of a 150 mm gravel substrate matrix (bottom layer) and a 350 mm sand matrix (top layer). In turn, category B reactors included gravel/sand and perlite. The B method of the substrate comprised three layers: a 150 mm gravel substrate matrix (bottom layer), a 300 mm expended perlite matrix (middle layer), and 50 mm of sand matrix (top layer). The study has been operated continuously for five-month.

Table 1. *The replication phases during the study period*

Study period, months	1-st month	2-nd month	3-d month	4th month	5th month
1 phase	hydraulic loading intermitting of 2 L / 4 d				
	irrigation with 10% synthetic strength wastewater				
2 phase			100% synthetic strength wastewater		
3 phase			IBU (500 μg L^{-1}) and DCF (100 μg L^{-1}) mixed with 100% synthetic strength wastewater and added into each CW system		

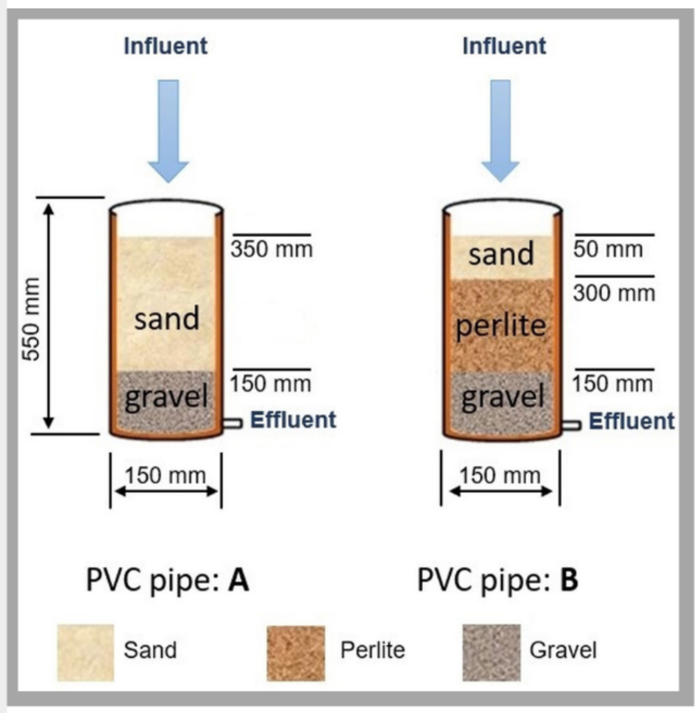

Figure 1. *Schematic diagram of experimental-scale CWs represents two filling methods of substrate: reactor A: 150 mm gravel layer and 350 sand layers reactor B: 150 mm gravel layer, 300 mm perlite layer, and 50 mm sand layer. Created by the author.*

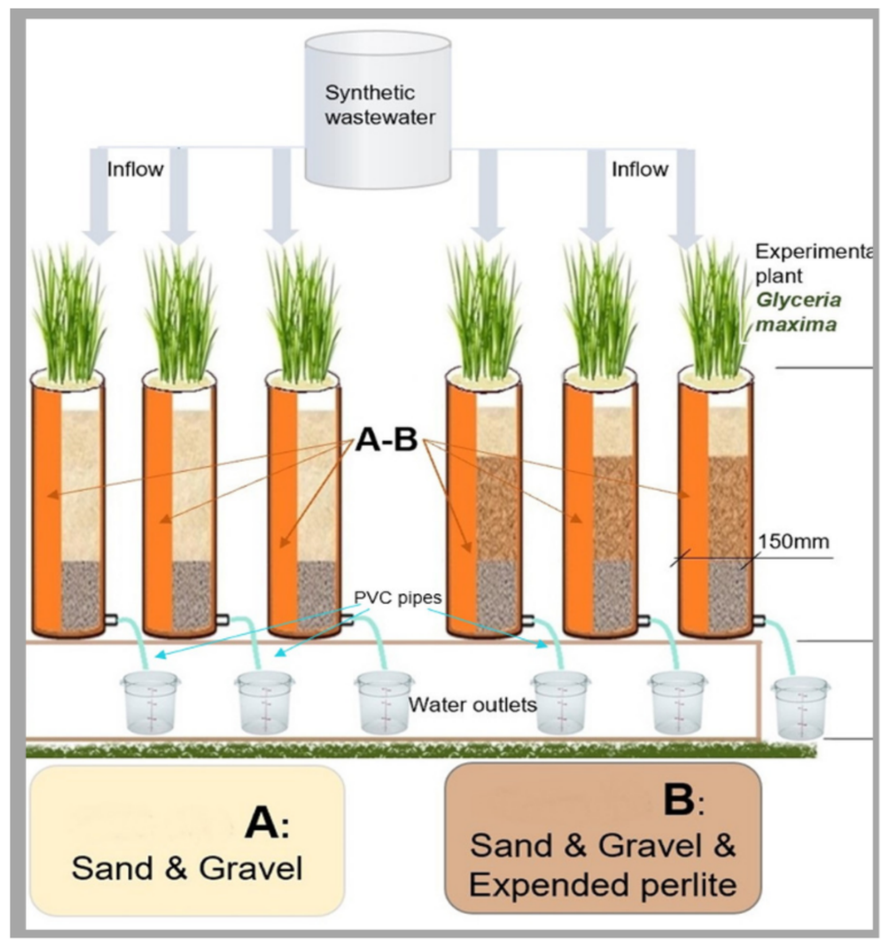

Figure 2. *Schematic diagram of laboratory scale. Characteristics of reactors. Created by the author*

Results

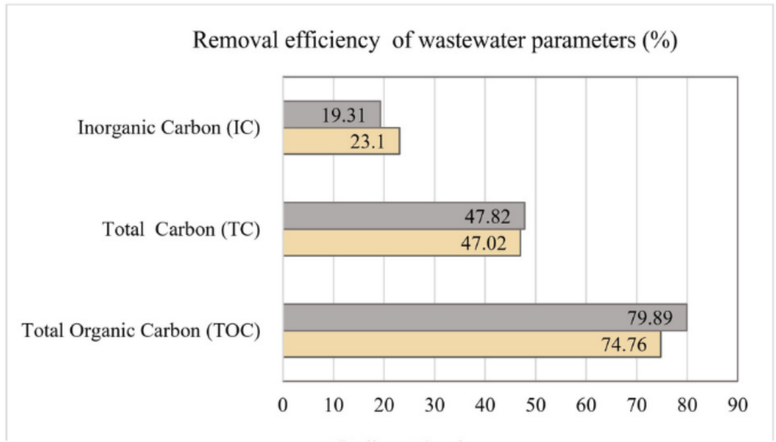

Figure 3. *The removal efficiency of IC, TC, and TOC (%)*

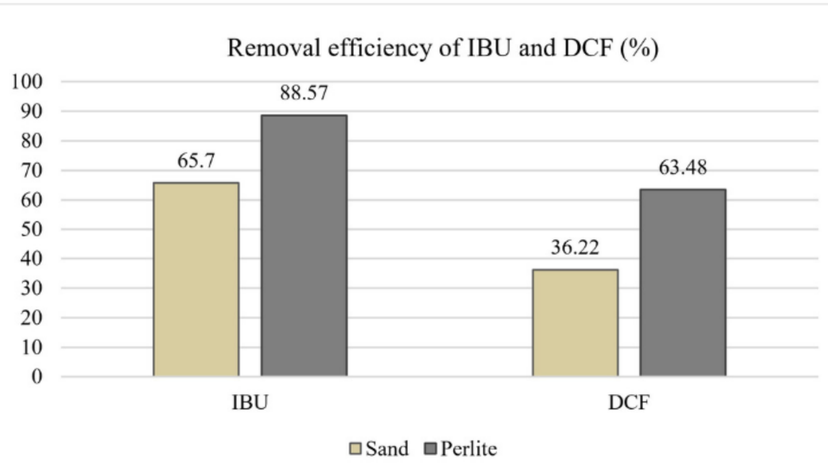

Figure 4. *The content of Ibuprofen and Diclofenac and their metabolites in the plant roots (μg kg-1)*

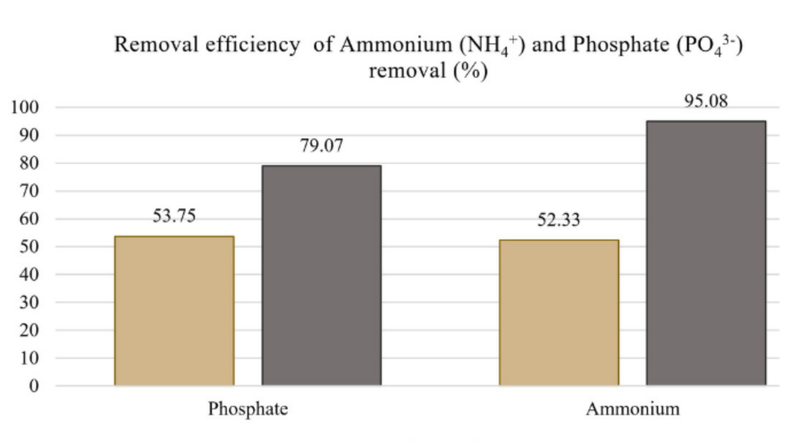

Figure 6. *The removal efficiency of Ammonium (NH4+) and Phosphate (PO43-) (%)*

Discussion & Conclusion

The study conducted above assists in getting an expanded practical knowledge concerning the aspect involved in the adsorption mechanism. It can be summarized that substrate plays a crucial role in the removal process. Our study has demonstrated that perlite coped better with issues and obstacles than the sandy filter. Therefore, it can potentially expand its usage in the adsorption process. Unfortunately, perlite is a non-renewable resource since it naturally occurs. Nevertheless, due to its low cost, and reuse ability, perlite is the most promising filter material for removing given emerging pollutants, including pharmaceuticals.

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POST- PROJECT ANALYZIS IN THE SENSE OF EIA EFFICIENCY FOR CONSTRUCTIONS OF ROAD TRANSPORT INFRASTRUCTURE

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DOI: https://doi.org/10.15414/2023.9788055226217

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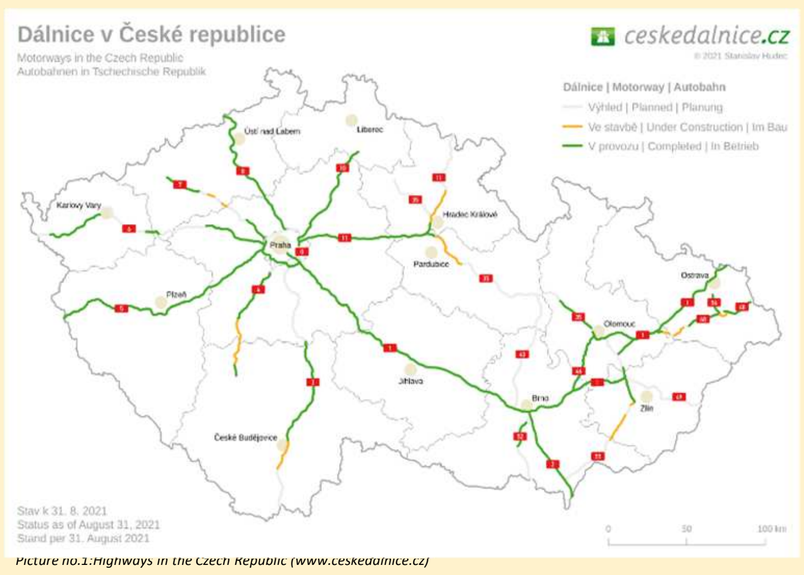
1)INTRODUCTION

Motorways and expressways always lead to a better quality of life for the populations who are dependent on transport in a given area and to improved access between individual destinations, but at the same time they have a very significant impact on the environment. According to protect the environment, the EIA process is also used, which helps to predict the individual types and significance of environmental impacts of a particular project in a particular area and also helps to identify measures to mitigate negative environmental impacts. The measures include not only the period before construction and during construction but also after construction. The question remains how effective this tool is? Post-project EIA analysis is one of the tools for evaluating the efficiency or effectiveness of the EIA process.

There are 1 362 km the total motorway network in the Czech Republic 158 km more is currently being implemented and 573 km of motorway constructions is being prepared. Considering this data there will be a massive construction of highway infrastructure in the near future. It can be expected a significant impacts on the environment of this constructions. With correctly evaluated data from our research, we can assist to the reduction of environmental impacts in the construction of new motorways and expressways.

Currently total highway network	Currently is being implemented – 25 projects	Projects in competition – 14 projects	Projects in preparation – 82 projects	Planned total network of highway
1362 km	158 km	78,8 km	573,4 km	2 169 km

Table no.1: Currently stay of highways in the Czech Republic (Directorate of roads and highways)



Picture no.1:Highways in the Czech Republic (www.ceskedalnice.cz)

Picture no. 2: Photo by Zdeněk Keken

Most of the countries of Western Europe have already gone through the state of highway infrastructure construction and are forced to deal with the consequences of strong landscape fragmentation during operation phase of the of the highway infrastructure. More than 700km of new highways remain to be build in the Czech Republic. It is necessary to learn from our own and foreign experiences and incorporate measures that can stop the landscape fragmentation or helt mitigate it into permitin processes, including the EIA process.

2) AIM OF STUDY

To evaluate previous EIA procesess within the transport infrastructure from the point of view of road ecology factors and to determine in what extent road ecology topics are included in defined preventive, elimination, minimization or. compensation measures.

These are mainly topics:

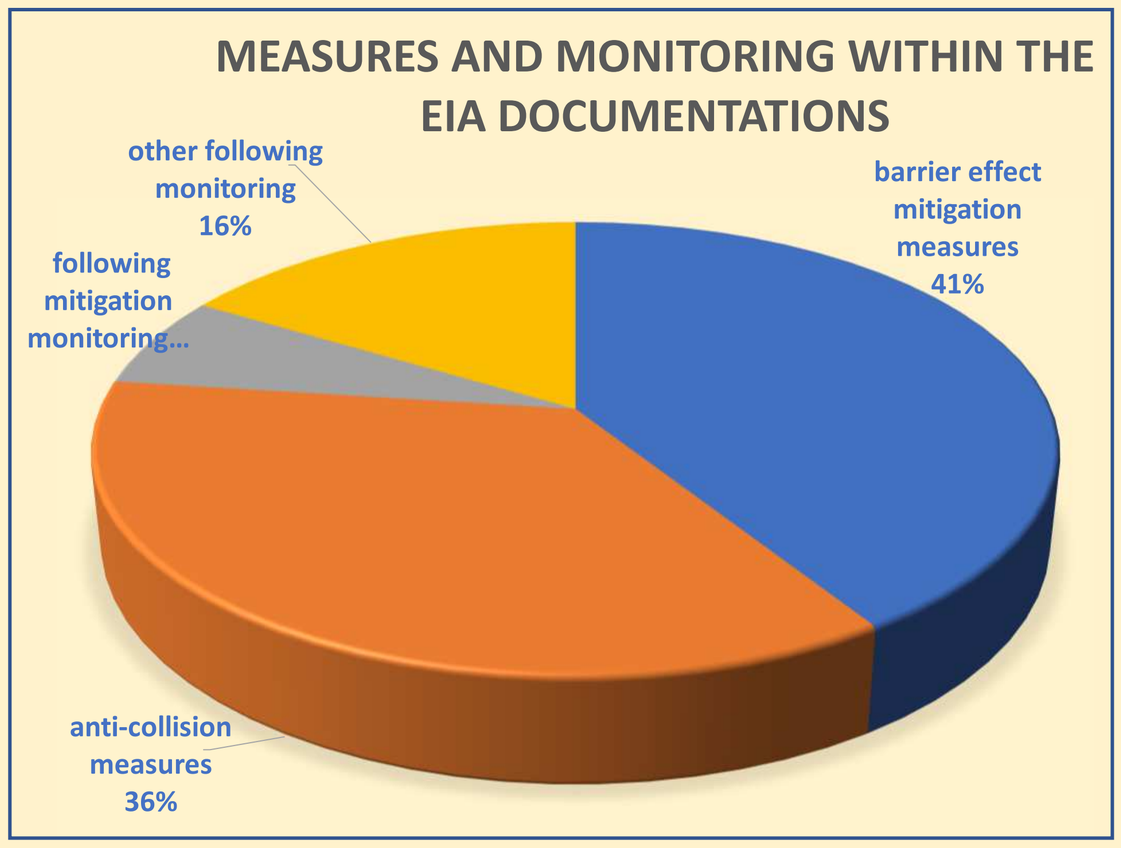
- Landscape fragmentation caused by highway infrstructure

- Permaebility of the landscape at the location of the highway infrstructure

3) METHODS

Post - project analysis:

- Selection of highway projects
- Data collection in EIA process database
- Selected parametres data evaluating using statictical methods
- Evaluation and verification of the impact of previous permitting processes on the preparation, implementation and operation of the construction
- Evaluation of results and recommendations for action



Pie chart no.1: Amount of measures and following monitoring requested in EIA procesess of highway projects

4) RESULTS AND CONCLUSIONS

They will be processed and published gradually according to the results of continuous measurements

Picture no. 4 and 5: Photos by Zdeněk Keken

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DEVELOPMENT OF CLIMATIC CONDITIONS AND SOIL MOISTURE IN THE NITRA RIVER BASIN IN 2021-2022

SUA·FHLE
Faculty of Horticulture and Landscape Engineering

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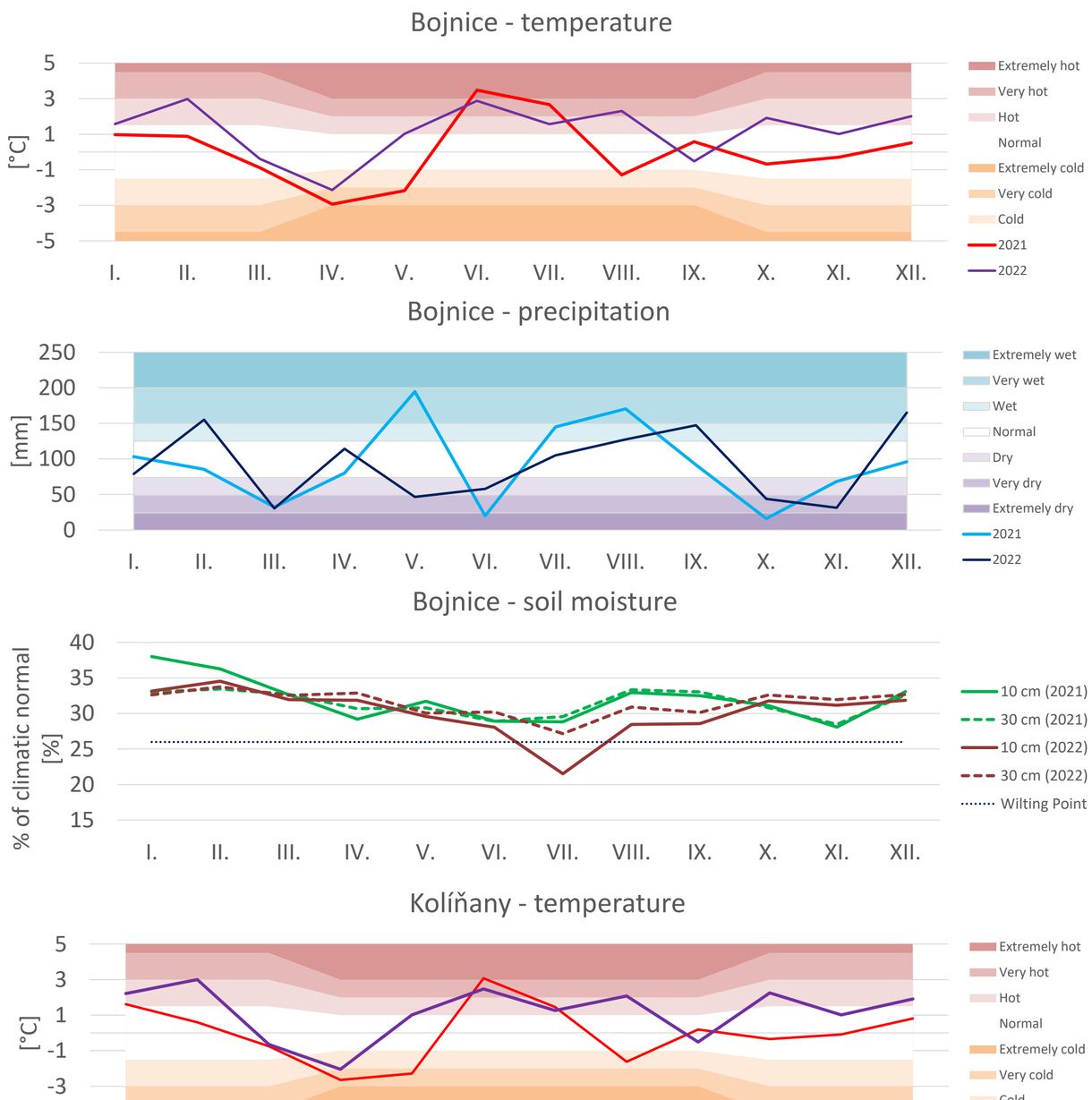
Slovak University of Agriculture in Nitra, Slovakia



Introduction

Based on the spatial average annual air temperature in Slovakia since 1931, the year 2022 was also the fifth warmest, with a value of 9.5 °C, while it was even warmer in 2014 (10 °C), 2018 and 2019 (9.8 °C) and 2015 (9.6 °C). The balance of precipitation in 2022 in Slovakia would have turned out to be even more negative if there had not been periods of heavy precipitation in the last three weeks of September and in some days of December. At the same time, stormy downpours, especially in the summer months, greatly affected the annual precipitation total (SHMÚ, 2023). The aim of the work was to evaluate the climatic conditions and soil moisture in the Nitra river basin in the years 2021-2023.

Research

The Nitra River Basin is located in the western part of Slovakia with an area 4501 km2. The territory belongs to the orographic subsystem of the Carpathian Mountains and the Pannonian Basin. In the basin is 61 % of the area agricultural land and 30 % of the area forest land (Tárník, Igaz, 2015). Temperatures and precipitation in 2021 and 2022 have been compared to the 1991-2020 climate normal and are shown in graphs. Soil moisture was also measured at depths of 10 and 30 cm and compared with the wilting point for a specific location (Bojnice, Kolínany and Príbeta).

Results

In terms of temperature, we observe a very cold April in all localities during this period, on the contrary, an extremely warm June compared to the climatic norm. In terms of precipitation, very dry to extremely dry months often alternate with very wet months. From the point of view of soil moisture, the most critical period was July 2022 at a depth of 10 cm, when the soil moisture reached below the wilting point at the Bojnice and Príbeta stations and approached this limit at the Kolínany station. From a long-term perspective, the year 2021 was also critical at the Príbeta station, when the soil moisture in 10 and 30 cm from July until almost the end of the year moved close to the wilting point.

Conclusion

The aim of this contribution was to point out the ongoing climate changes and the related fluctuations in the distribution of precipitation, temperature changes and the related development of soil moisture. Based on these data, we can predict the future development of soil moisture and optimize the need for irrigation of field crops.

Acknowledgements

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THE EFFECT OF CLIMATE CHANGE ON THE NUMBER OF TROPICAL NIGHTS IN SLOVAKIA

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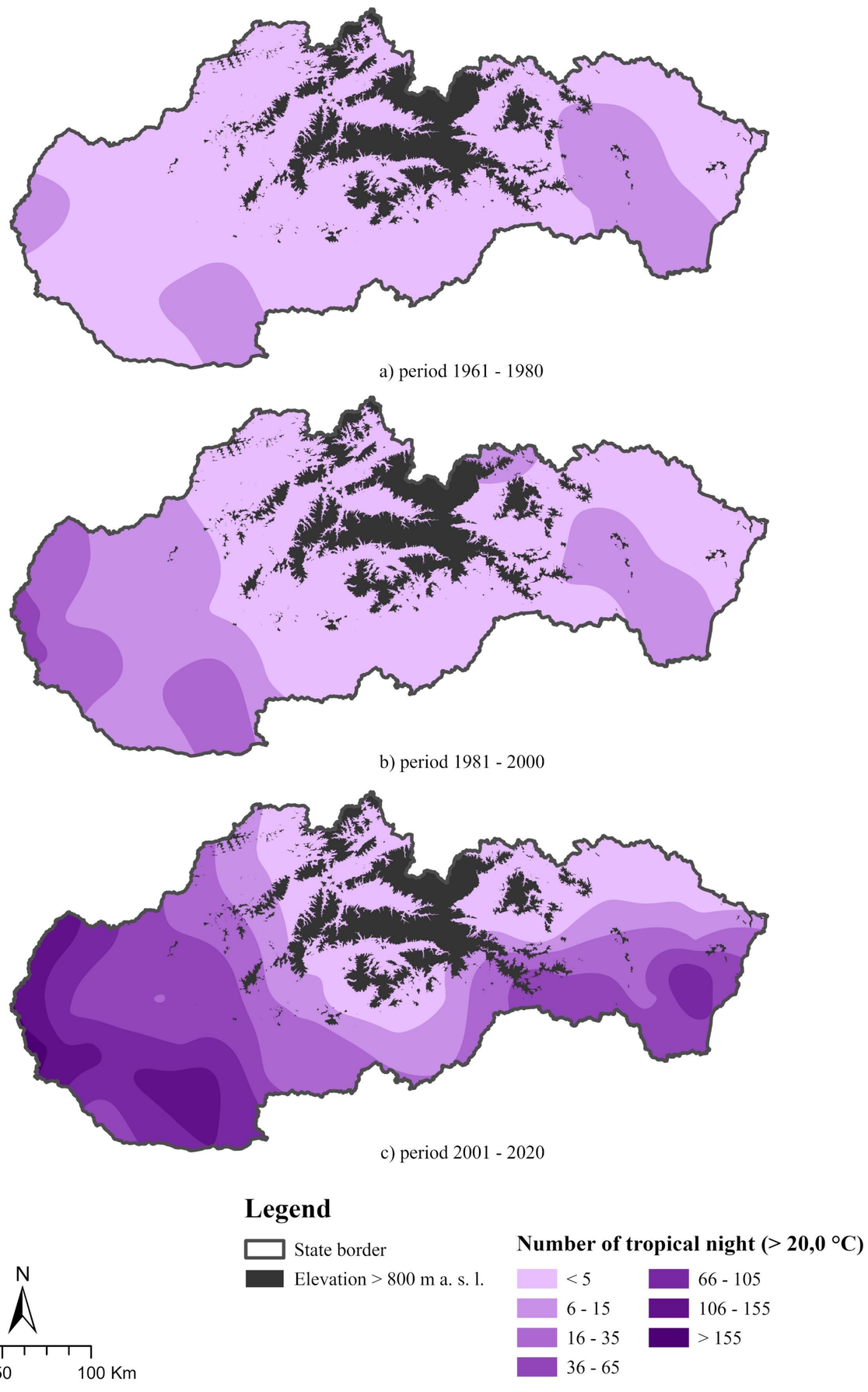
Faculty of Horticulture and Landscape Engineering



Introduction

The State of the Global Climate 2022 points to planetary-scale changes in the land, oceans and atmosphere caused by record levels of concentrations of heat-trapping greenhouse gases. In terms of global temperature, the years 2015 to 2022 were the eight warmest years on record. The average global temperature in 2022 was 1.15 (1.02 to 1.28) °C above the 1850-1900 average (SHMÚ, 2023). As the average daily temperature increases, so does the minimum night temperature. The aim of this post is to highlight the increasing number of tropical nights in periods 1961-1980, 1981-2000 and 2001-2020.

Research

The aim of this study is Slovak Republic. The country is situated in Central Europe (from 47° 44' 21'' up to 49° 36' 48'' of northern latitude and from 16° 50' 56'' up to 22° 33' 53'' of eastern longitude) with surface area 49,037 km^2. The territory belongs to Alpine-Himalayan belt system – the Carpathian Mountains are rimmed by plains of Pannonian Basin in the south. The location creates a transitional climate between maritime and continental, although the climate is mostly determined by altitude (SHMÚ, 2015). The number of nights with minimum temperatures above 20 °C (tropical nights) were calculated by statistical analysis for the decades 1961-1980, 1981-2000 and 2001-2020. The processed data together with the coordinates of the stations were entered into the ArcGIS software. From the point data, surface data between individual stations were created using interpolation. From several interpolation methods provided by ArcGIS, the "Topo to Raster" method was chosen, which uses an interpolation method designed to create continuous surfaces from contours (ESRI, 2023). Subsequently, these values were divided into categories and map outputs were created.

Results

The study shows that the number of tropical nights has increased rapidly. During the years 1961-1980, tropical nights occurred in most of the territory for up to 5 nights with a minimum temperature T min > 20 °C. Only in some localities (Prešov, Podhájska) did up to 15 tropical nights occur. During the period 1981-2000, the number of tropical nights increased especially in the Danube Plain, where it represented an increase of more than 20 tropical nights in 20 years, and in Bratislava there were up to 40 tropical nights. The most radical increase is in the period 2001-2020. Over 100 tropical nights occur in the southern parts of Slovakia (Danube Lowland) and over 70 tropical nights in the east of Slovakia (Somotor, Michalovce). The biggest increase is up to 174 tropical nights in Bratislava.

Conclusion

Climate change affects every aspect of life. Agriculture is no exception. High temperatures affect the fertility and quality of crops. Another negative is the formation of high evaporation and drying of the soil. In addition to the fact that extreme maximum temperatures are occurring more and more often, high minimum temperatures are also a problem, as we pointed out in our post. Based on these data, it is necessary to take measures to mitigate climate change.

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Veda mladých 2023 - Science of Youth 2023

PROCEEDINGS OF PAPERS FROM A SCIENTIFIC CONFERENCE

Nitra, Slovakia
30.05.2023

Held under the auspices
prof. Ing. Dušan Igaz, PhD., dean of FHLE SUA in Nitra.

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