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USE OF BIOSTIMULANTS IN VEGETABLE PRODUCTION

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Abstract

Growing both high-quality vegetables with yields sufficient for profitable production is usually quite challenging for the farmer. Despite many significant innovations and discoveries in the field of agriculture, the situation is complicated by increasing climate changes and worsening pressure of abiotic and biotic stress factors on plants. At the same time, the strict standards that vegetable growers are being complied with, also pose a considerable problem. One of the most widely used ways for achieving market requirements is the proper use of plant biostimulants. These biological preparations are not only irreplaceable in the conventional growing system, but also in an integrated and ecological growing system while being able to reduce the need for pesticides and chemical fertilizers. This fact makes the harvested crops even more attractive for consumers, who are increasingly interested in healthy organic food. However, the portfolio of biostimulants is so diverse that growers do not know which could be appropriate for their needs and thus do not trust them sufficiently. The aim of this review was to summarize the basic types of available plant biostimulants based on content substances or microorganisms while focusing on explaining their functional processes and tools with their impact on plants.

Keywords: biostimulants, vegetables, climate changes

Introduction

Vegetables are grown worldwide in almost 200 countries and make up a major portion of the diet of humans in many parts of the world. Vegetables play a significant role in human nutrition, especially as sources of vitamins (C, A, B1, B6, B9, E), minerals, dietary fiber, and phytochemicals. Each vegetable group contains a unique combination and amount of these phytonutriceuticals, which distinguishes them from other groups and vegetables within their own group (Dias, 2012). Research activity in the matter of agriculture systems has for years been oriented to increase yield without considering the quality of the product and the rational use of resources. In contrast, attention now is mainly focused on product quality and the sustainability of the cultivation systems. Moreover, cultivation management pays more attention to the reduction of production costs by lowering inputs (Bulgaria et al., 2015). On the other hand, in the case of many important crops, increased abiotic and biotic stress is a major cause for productivity stagnation. It has been considered as a big difficulty to develop efficacious, low-cost, and easy-to-apply methods in abiotic stress management. Many studies have been conducted throughout the world for a purpose (Altuntaş and Kutsal, 2018). In the face of degraded agricultural areas and uncertainties related to the changing climate, biostimulants use can be an interesting option (Parađiković et al., 2018). Plant biostimulants are usually applied to high-value crops, mainly greenhouse crops, fruit trees, open-field vegetables, flowers, and ornamentals to increase yield and product quality in a sustainable way. These biological preparations were initially used in organic production but now they are increasingly being introduced in conventional crop production to respond to economic and sustainability imperatives (Giuseppe and Rouphael, 2015). Biostimulants have been gaining also interest in sustainable agriculture because their application activates several physiological processes that enhance nutrient use efficiency, stimulating plant development and allowing the reduction of fertilizers consumption. Many biostimulants are also able to counteract the effect of biotic and abiotic stresses, enhancing quality and crop yield by stimulating plant physiological processes but they are not fertilizers and typically do not have a direct action against pests (Bulgaria et al., 2015; Yakhin et al., 2017). In 2012, the global market of biostimulants was mainly located in Europe and it is projected to increase by 12% annually, reaching $2,241 million by 2018. Despite their growing use, there is currently no accepted definition of biostimulants, neither by regulatory bodies nor by the scientific community. However, with the revision of the current European Union (EU) legislation on fertilizers, there has been some progress (Le Mire et al., 2016). According to Traon et al. (2014), cited in (Parađiković et al., 2018) "A plant biostimulant is any substance or microorganism, in the form in which it is supplied to the user, applied to plants, seeds or the root environment with the intention to stimulate natural processes of plants benefiting nutrient use efficiency and/or tolerance to abiotic stress, regardless of its nutrients content, or any combination of such substances and/or microorganisms intended for this use."Inevitably, as our understanding of the molecular networks that control plant growth improves our ability to predict plant response to biostimulants under specific environmental conditions, will improve. Only through a combination of methodologies will progress in biostimulant research be possible (Yakhin et al., 2017). There is no exact definition of main plant biostimulants categories. But according to the statement of many studies as (Chiaiese et al., 2018; Woo and Pepe, 2018; du Jardin, 2015), we can divide them to 4 most important groups what are using in commercial formulations: humic substances (humic and fulvic acids); amino acids, Protein hydrolysates, chitosan and other biopolymers; algae or plant extracts; beneficial microorganism (fungi or bacteria).

Material and methods

The article was elaborated as a review while the latest available literature and scientific publications have been processed for its compilation.

Results and discussion

Algae extracts

The chemical synthesis of biologically active compounds is usually quite problematic and difficult. Many author report, that the best source of these compounds should be algae extracts (Michalak et al., 2016). The benefits of seaweeds as sources of organic matter and fertilizer nutrients have led to their use as soil conditioners for centuries (Khan et al., 2009). These extracts containing natural active compounds comprise a wide variety of structures and functions that provide an excellent pool of molecules for the preparation of nutraceuticals, functional foods, food additives, and biological agrochemicals. Oancea et al., 2013; Chiaiese et al., 2018 reported in their studies, that both micro or macro-algae produce several complex macromolecules that are active on higher plants. Extracts of brown, green and red macroalgae (seaweed), which are mainly collected from seawater, represent an important category of organic biostimulants. Macroalgal extracts show identifiable amounts of active plant growth substances with the ability to enhance antioxidant activities in plants under abiotic stress by improving physiological fitness of the treated crop plants. These formulations are a complex mixture of components (i.e. laminarin, fucoidan, alginates, and minerals) that may vary according to the macroalgal source, the season of collection and the extraction process used (Sharma et al., 2016). Overall, a wide array of chemicals has been identified in seaweed extracts including polysaccharides, phenolics, fatty acids, vitamins, osmolytes, phytohormones, and hormone-like compounds. But that is not all. Algae contain important quantities of plant growth hormones, auxins, abscisic acid, cytokinins, gibberellins, brassinosteroids and polyamines as putrescine and spermidine (Oancea et al., 2013; Michalak et al., 2016; Chiaiese et al., 2018). Oancea et al., 2013reports that cytokinins have been proved to be one of the main active ingredients in seaweed extracts used as plant biostimulants, while commercial seaweed extracts, especially those made from *Ascophyllum nodosum* and *Ecklonia maxima*, contain between 0.1-1.0 mg.l^{-1} total cytokinins. Due to the fact that contains the large quantities of polyamines and betaines are significantly involved in plant adaptation to abiotic and biotic stress. However, it is not only the effect of these substances. The application of algal biostimulants on vegetable plants should bring multiple benefits, including better rooting, higher crop yields, stronger drought tolerance, enhanced photosynthesis activity, better resistance to fungi, involved in signaling plant response to abiotic stress, improvement of seedling establishment, flowering and fruit setting as well as a post-harvest shelf life and minimizing the use of expensive chemical fertilizers. Macroalgal biostimulants are able to enhance the nutrient concentration and nutrient uptake, especially under various stress conditions. The application of seaweed onto vegetable plants was observed to induce an increased content of N, P, K and Ca (Szczepanek et al., 2015; Shalaby and El-Ramady, 2014; *Oancea et al., 2013;* Michalak et al., 2015). In the study of Chiaiese et al., 2018 are referred various cases of algae extract effect on vegetable under open-field or greenhouse conditions. They stimulated germination, seedling growth, shoot, and root biomass in many horticultural crops such as lettuce, red amaranth, pack choi, tomato, and pepper. For lettuce germinated in a medium containing *C. vulgaris* was observed better growth (on both fresh and dry weight basis), plant growth (i.e., shoot, root dry weight, and length) while also improved the photosynthetic activity what leads to better carotenoid and chlorophyll content. Other similar examples should be improving plant growth by the application of *Spirulina platensis* to different leafy vegetables such as rocket, bayam red, and pakchoi. What more, they mentioned, that similar effect was also on various fruit vegetables, such as tomato and pepper. *D. salina* exopolysaccharides mitigate the effect of different salinity levels in tomato by increasing the antioxidant enzymatic activity, phenolic compounds and key metabolites such as neophytadiene, tocopherol, stigmasterol, and 2,4-ditert-butylphenol, which are considered components of the main mechanisms against oxidative stress. Dudaš et al., 2016 stated that application of *Ecklonia maxima* (Osbeck) extract on *L. sativa* L. cv. Winter Crisp had also positive results. Seaweed concentrate triggers early flowering and fruit set in a number of crop plants. For example, tomato seedlings treated with SWC set more flowers and earlier than the control plants and this was not considered to be a stress response but also increased fruit yield, producing large-sized fruits (30% increase in fresh fruit weight over the controls) with superior quality. Similar foliar application enhanced harvestable yield in lettuce, whereas an increase in the heart size of the florets and curd diameter was observed in cauliflower. But the better yield was observed also for bell pepper, beans (by 24%) and other crops, while positively were influenced also abiotic and biotic stress tolerance of plants (Khan et al., 2009). Similar results presented also Halpern et al., 2015, they state that the application of seaweed to leaves or roots lead to an increase in plant and yield biomass for many vegetable species, such as cucumber, rocket, tomatoes, mung bean but also in strawberries. What was probably caused by auxins or cytokinins in algae or by larger, more robust root system contributes to better nutrient uptake. In a different study Szczepanek et al., 2017stated that the application of seaweed granules to the soil is capable of reduction diseases severity on bulbous vegetables (Downy mildew in *Allium cepa* L. and Alternaria leaf spot in *Alium fistulosum*). They also mention that the beneficial effects as an increasing yield were shown in many cultivated crops and in onion cultivation practices with the use of seaweed extract significantly increased the percentage of marketable onions after storage so it´s a possible advantageous way to increase the quality of yield. These results were also confirmed, in their experiment. In another study of Trinchera et al., 2014 is mentioned that *Ascophyllum nodosum* extracts were able to improve seedlings emergence and vigor in many crops, being their plant-growth promoter activity yet recognized by reference bioassay on "model" crops. It was proven also by their greenhouse trial when this seaweed extracts significant increases of lettuce shoot dry weight, shoot dry matter, specific leaf dry weight, root dry weight, and total dry biomass.

<u>Humic substances</u>

Humic substances are formed by chemical and biological transformations of plant and animal matter and from microbial metabolism and represent the major pool of organic carbon at the earth's surface (Canellas et al., 2015). Biostimulant effects of humic substances are characterized by both structural and physiological changes in roots and shoots related to nutrient uptake, assimilation, and distribution (increased proliferation of root hairs, production of smaller but more ramified secondary roots, and enhanced root initiation). By the application of a humic substance to plants, its application also results in productive and fertile soil which increase the water holding capacity of soil as well as soil aeration, water regime or establishing an appropriate environment for the development of beneficial soil microorganisms. And thus the application of Humic reduces the requirement of other fertilizers (improve nutrient use efficiency traits). A benefit of humic acid is also due to its ability to complex metal ions and form aqueous complexes with micronutrients and may form an enzymatically active complex. All of this resulting in induce shifts in plant primary and secondary metabolism related to abiotic stress tolerance which collectively modulates plant growth as well as promoting fitness, so the plant has better resistance against many types of stress factors. But that´s not all, they inducting chlorophyll biosynthesis or enhanced the production of growth-promoting hormones, including cytokinins or auxins as well as many other beneficial effects (Bulgaria et al., 2015; Sajid et al., 2012; Said et al., 2017; Canellas et al., 2015; *Shahein et al., 2015*). The most important substances belonging to humic are fulvic and humic acids. Usually is a better crop response observed after using humic substances obtained from compost or vermicompost than leonardite (what is the most common commercial source, used in majority commercial preparations), and better effect have humic acids than fulvic acids (Canellas et al., 2015). Humic acid is a complex molecule and is considered an alkali-soluble, polymeric organic acid of aromatic structure substituted by carboxyl, phenolic, hydroxyl and alkyl groups linked together by ester linkages. We can meet a variety of different studies supporting their positive effect on plants. One of them is an example when the application of humic substances increased the yield in soybeans, potatoes or fruit yield and quality of squash plants. Humic acid and their interaction had a significant effect on all onion cultivars in another experiment. What more, there are experiments where potatoes and cabbage after application of classical NPK fertilizers combined by application of Humics achieved 100% increase in the yield (Sajid et al., 2012). Shalaby and El-Ramady, 2014 stated that garlic plants sprayed with humic acid had better storability (lower bulb weight loss) than untreated ones. These results may be due to the effect of humic acid on growth parameters which may reflect on enhancing the quality and storability. In other studies (Parađiković et al., 2018; Canellas et al., 2015) referred that humic substances were able to in many experiments promote vegetable crop growth, enhance commercial quality/marketable values of vegetables or decrease of the incidence of plant disease. The enhanced nutrient use efficiency and marketable yield by 15% of broccoli plants. Increased seed germination, yield, nutrient uptake, root length and weight of broad bean and similar stimulative effects were observed also on seed germination in an experiment with parsley, celery, and leek seed soaked with a 1% (v/v) humic acid solution. Influenced the kinetic parameters of K uptake and increased nutrient uptake by 41% on root dry weight, but also enhanced yield by 25-35% in case of common beans. In other experiments increased growth and development, nutrient uptake and flowering of cucumbers. For eggplants increased N use efficiency and fruit yield from 23 to 63%. Application to garlic had better efficiency of mineral nutrition and also bulb yield, quality and storage properties (2 - 6%). It shortened the growing cycle of lettuce. For muskmelon increased fruit yield (18% of fruit fresh weight), fruit soluble solids, firmness and linear increment in the fruit diameter, decreased powdery mildew incidence and increased nutrient use efficiency. In more cases markedly increased total yield, root fresh weight as well as the marketable yield of onion bulbs (by 26%). They also stated that for okra were shoot and tap root length, a number of leaves per plant, leaf area significantly increased while reduced *Choanephora* wet rot incidence by 76%. Important was also the influence of humic on pepper and tomato. For these two crops were observed many positive effects. They also reported about 8 different studies, while application increased plant dry matter production by up to 560% or led to significantly higher mean fruit weight and early and total yield than control. The total yield of pepper fruit was enhanced by 13% but for tomato by 44–80% while the decreased incidence of Phytophorainfestans and increased the fruit sugar content. Moreover, humic acids were able to improve Fe- nutrient uptake and quality of tomato plant also under hydroponics. The humic acid application was statically found to be effective in a number of experiments. 0.8% humic acid application has increased the yield at the rate of 68% in cress, 57% in rocket and 78% in sorrel. 0.4% humic acid dose in terms of leaf length and leaf width gave an increase for 63.15% and 34.55% respectively in rocket plants (Ugur et al., 2013). Adamec et al., 2018 also stated, that within their experiment had the application of biostimulants positive effect on the yield of sweet pepper fruits and fruit quality. Especially in case of Agriful application - preparation based on humic and fulvic acids recorded more than 20% increase in total yield while only a minimum of fruits was in substandard class. However, vitamin C or total carotenoids content were not affected in this case.

<u>Beneficial microorganisms</u>

There is a growing worldwide demand for compatible environmentally friendly techniques in agriculture, capable of providing adequate nourishment for the increasing human population and of improving the quality and quantity of certain agricultural products. For these reasons, the application of beneficial microorganisms is an important alternative to some of the traditional agricultural techniques which very often severely alter the agro-ecosystem balance and cause serious damage to health. Beneficial microorganisms can play a key role in this major challenge, as they fulfill important ecosystem functions for plants and soil (Altuntaş and Kutsal, 2018). As (du Jardin, 2015; Yakhin et al., 2017) stated in their study paper that the concept of microorganism-based preparations as biostimulants is described by many authors and microorganisms are frequently and successfully using for this purpose. They can be applied directly as a living organism or used for the production of various biostimulant formulations containing non-living microorganisms and their natural substances. Microorganisms include beneficial bacteria, mainly ‘plant growth-promoting rhizobacteria’, and beneficial fungi. They can be free-living, rhizospheric or endosymbiotic. In recent years, a large number of various beneficial effects of microorganisms have been observed on vegetables as well as plants overall. In doing so, they often depended on individual groups of microorganisms as well as cultivated crops and environmental conditions. However, it is very difficult to determine the exact effects of these preparations. Each individual species, but even their isolated strains, have a specific impact on soil and cultivated plants (Le Mire et al., 2017; Woo and Olimpia, 2018; Chen et al., 2002). First very interesting example of positive plant-microbe interactions include PGP (Plant growth promoting bacteria: non-pathogenic *Pseudomonas, Alcaligenes, Burkholderia, Enterobacter, Bacillus, Azotobacter, Serratia, Azospirillum, and Rhodococcus, are* capable of improving nutrient availability in soil, plant nutrient uptake and assimilation, as well as improving plant adaptability and response to various biotic and abiotic stress factors. All of this naturally resulting in promoting of plant growth, crop yields and lower costs for farmers (Woo and Pepe, 2018; Altuntaş and Kutsal, 2018; Ipek et al., 2014). For example, *Azotobacter* species are found in agricultural soils playing different beneficial roles: atmospheric nitrogen fixation, secrete plant growth promoting and regulating substances such as phytohormones, vitamins, and antifungal metabolites, degradation of toxic compounds and driving the ecological balance in agro-ecosystems or solubilization of phosphates and Fe mobilization. All of this was observed on many vegetable species, such as broccoli, zucchini, spinach, tomato or carrot (Woo and Pepe, 2018; Jiménez et al., 2011). There are really many experiments supporting these results. Just positive effects of *Bacillus* M3 (strain) are confirmed on the yield and growth of crops such as chickpea, spinach, tomatoes, sugar beet, but also fruits like strawberries and apples and many other crops, explained by N-fixation ability, phosphate solubilizing capacity, indole acetic acid (IAA) and cytokinin production. And is not an exception, when bacterial applications have increased fruit number between 14.5 and 34.7% (Ipek et al., 2014). In the different study was commercial preparation with *Pseudomonas putida*, *Azotobacter chroococcum*, *Bacillus circulans*, *B. megaterium* able to significantly improve tomato total yield, marketable yield, and yield of soluble solids content (°Brix) while their results were supported by many other similar (Pék et al., 2018). Arbuscular mycorrhizal fungi (AMF), which are useful organisms, have a significant role in performance and nutrition with plant mineral intake capacity. Putative mechanisms involved in interactions between AM fungi and organics include direct effects of enzymes secreted by hyphae, and indirect effects of enhanced root-derived enzymes, microbial activity and modified microbial composition, and unspecific effects of changes in pH, osmotic potential, redox potential, partial pressures of O_2/CO_2. AM fungi also make a direct and/or indirect contribution to enhancing the biodegradation of organophosphorus pesticides and consequently decreasing pesticide residues in crops grown in polluted sites. The mycorrhizal horticultural products have high phytochemical elements (carotenoids, flavonoids, and polyphenols) and therefore meet the desires of consumers and authors with their health/benefit influences. Furthermore, AMF also brings tolerance to drought and salinity, nutrient deficiency, heavy metal contamination and in adverse soil pH (Wang et al., 2011; Altuntaş and Kutsal, 2018). Overall, the AM fungi association is most beneficial to crops grown in fields with low soil test P levels because of the fungus increase availability, uptake and indissoluble of immobile phosphate ions in soil with the interactions with bi/trivalent cations (especially Ca^{2+}, Fe^{3+}, and Al^{3+}. The main mechanisms in this mutualism are the ability of AMF in developing external hyphae networks that may extend the surface area (up to 40 times) and the explorable soil volume for nutrient intake by producing enzymes or excreting organic substances (Altuntaş and Kutsal, 2018; Elbon and Whalen, 2015). It is confirmed by many experiments while there were usually, observed much bigger yields for the mycorrhizal than non-mycorrhizal crops. As a good demonstration should serve Welsh onion (*Allium fistulosum*) inoculated with AM fungi that received 300 mg P_2O_5 kg^{-1} soil, produced yields that were comparable to non-mycorrhizal Welsh onion fertilized with 1000 mg P_2O_5 kg^{-1} soil. In other experiment was onion yield was two to three times greater in mycorrhizal than non-mycorrhizal plants, whereas mycorrhizal bell peppers and soybean that received single superphosphate fertilizer had a great increase in yield, and mycorrhizal yielded a more times greater than non-mycorrhiza in the absence of P fertilizer. While it was similar for leek and tomato (Elbon and Whalen, 2015). AM fungi were also able to enhance the yield of carrot and green onion and simultaneously decrease the concentrations of organophosphorus pesticides in both plants and soils, but the effects vary with AM fungal species, host plants, and pesticide application rate. Addition mycorrhiza supported the tolerance of host plants to pathogens, and thus decrease the amount and frequency of pesticides application, and improve crop quality (Wang et al., 2011). In the experiment of Anrejiová et al., 2016 was observed a statistically significant effect of the mycorrhizal preparation on all evaluated growth parameters of tomato (overground plant mass, the weight of the root system, plants height) while had also a positive effect on total yields of tomato fruits for both selected varieties. Among the most frequently used AM fungi with proven positive effects on crops include species from the genus: *Gigaspora, Funneliformis* or *Rhizophagus* (*Glomus)*, and *Laccaria.* Another case is the fungus *Trichoderma*. It is an active ingredient in hundreds of agricultural products commercialized worldwide and it has multiple beneficial effects on plants as a biostimulant or biocontrol agent used extensively especially in biological and integrated pest management. In addition to their biopesticide activity, some Trichoderma strains have been proven to have a biostimulant activity, plant growth promotion, improved yield and nutritional quality, as well as mitigating the detrimental effect of abiotic stresses (Woo and Olimpia, 2018; Fiorentino et al, 2018). *Trichoderma* spp. produce over 250 metabolic products including cell wall degrading enzymes, peptides, secondary metabolites, and other proteins. Many of these compounds are bioactive and can affect the plant response to other microbes, by improving defense mechanisms, while stimulating plant growth and development, especially at the root level (Woo and Pepe, 2018). For example, Trichoderma-based biostimulants positively affected both lettuce and rocket yield in the unfertilized plots but with higher dosages of fertilizers, the efficiency is decreasing. Also, the total ascorbic acid content in both leafy vegetables was significantly influenced (Fiorentino et al.,2018).

Other substances

The great positive effect of these substances should be shown on the example of drought stress. Water scarcity is one of the main factors limiting plants productivity. It causes reduction of chemical water potential and water transport inhibition, reduces hydrostatic pressure in the cells, impairs the transport of macromolecules, limits the proper functioning of cell membranes and disorganizes cooperation between cellular organelles while changes at the cellular level are reflected in the growth and plant development. Osmotic adjustment is an indication of the plant adaptation to drought conditions, which consists of the solute accumulation in cells in response to changes in the water potential. In different stress conditions, plants accumulate compatible solutes and these can be also applied to the soil as biostimulants (Możdżeń et al., 2015). Whereas primary metabolites: amino acids (proline arginine and tryptophan), sugars (glycosides and polysaccharides), nucleotides, lipids, alginates or mannitol are contained in most preparations *de facto*, the presence of secondary metabolites is more specific and depends to a large extent on the raw material used (species, tissue, growing conditions). Secondary metabolites are formed from different primary metabolic pathways, including glycolysis, the tricarboxylic acid cycle (TCA), aliphatic amino acids (AA), the pentose-phosphate and shikimate pathways which are primarily the source of aromatic AA and phenolic compounds (PC), terpenoids/isoprenoids, nitrogen-containing compounds (alkaloids), sulfur-containing compounds (glucosinolates) (Yakhin et al., 2015; Sharma et al., 2016). Probably the most used biostimulants from this group are the amino acid-based products consist of a balanced mixture of free and short chain peptide-bound amino acids. These fractions (i.e. proline and arginine) including polypeptides have been demonstrated by foliar applications, to regulate biochemical and physiological functions in the plant resulting in improved resistance to abiotic and biotic stresses. Protein hydrolysates containing amino acid and peptides can be of either animal or plant origin, manufactured by chemical or enzymatic hydrolysis (Sharma et al., 2016). Application of protein hydrolysates can alleviate the negative effects of abiotic plant stress due to salinity, drought and heavy metals. Its also directly affecting plants by stimulating carbon and nitrogen metabolism, and interfering with hormonal activity and indirectly by enhancing nutrient availability and uptake or by stimulation of plant microbiomes. However, as observations have shown these substances are more effective if they are of plant origin. Many experiments on vegetable crops proved this amino acid effect. For instance, corn, lettuce, pepper, and tomato as well as fruit species: apples, kiwifruit, papaya, passionfruit. Other studies show a positive effect of foliar application of amino acid mixtures on plants, such as increased productivity in *Solanum lycopersicum* and higher accumulation of dry matter mass, chlorophylls, carbohydrates and polysaccharides in *Viciafaba*. The application of mixed amino acids could substantially reduce nitrate accumulation in several leafy vegetables such as lettuce, rocket (*Eruca sativa* Mill.), Swiss chard (*Beta vulgaris* var. *cicla* L.) and spinach (*Spinacea oleracea* L.). The growth of eggplant, tomato, and Indian mustard was also promoted by the addition of plant growth promoting peptides derived from soybean (Colla et al., 2017; Teixeira et al., 2018). Similar results were recorded in an experiment with plant-derived protein hydrolysate "Trainer" which significantly influenced growth parameters of corn, pea, and tomato (elicited an auxin and gibberellin-like activity, enhanced nitrogen uptake, and crop performance) (Colla et al., 2014). Another very potential biostimulant is chitosan. Chitosan is a biodegradable compound found naturally and is derived from crustaceous shells. It´s proven his positive effect on control of several diseases of horticultural crops both in pre and postharvest stages, as well as the foliar application of chitosan, increased plant growth, yield, and quality of bean plants, radish and cucumber (Mahmood et al., 2017). But, that not all, many researchers reported that using chitosan as foliar spraying improved the vegetative growth, yield and quality of some vegetable and fruit crops such as strawberry, garlic and sweet pepper. Another substance is citric acid, which improved the growth and increased the yield chlorophyll content of vegetables (Abdelgawad et al., 2018). Very positive results as a biostimulant have also ascorbic acid. Garlic plants treated with ascorbic acid recorded the lowest percentage of bulb weight loss during storage. What more, high quality of bulbs were obtained during 300 days of storage when plants were sprayed with ascorbic acid. It is supported by more authors, that plants sprayed with humic acid had better storability than untreated ones. These results correspond with the effect of humic acid on growth parameters which may reflect on enhancing the quality and storability of garlic bulbs (Shalaby and El-Ramady, 2014).

Conclusions

It is nothing extraordinary that from year to year we will receive new serious pests or vegetable diseases. In spring, late spring frosts cause problems, in summer the temperature rises above 40° C and we have long periods without rainfall. Along with the still ever-decreasing soil quality and rising water and fertilizer prices, these problems are devastating for many vegetable growers. However, these problems can be partially solved, and not only by the application of chemicals or high investments in technical equipment. As summarized in our study, one of the best ways how to successfully fight with various adverse abiotic and biotic conditions is to support plants in their struggle by applying biostimulants. This method is used in the world by all the biggest growers and deserves more attention also in Slovakia. In addition to better plant resistance, the farmer can harvest significantly greater and better quality yields, while lowering chemistry costs and, last but not least, improve the quality of the growing environment. However, the use of biostimulants is not always the simplest. Their effectiveness and the meaning of their use depend on many factors, such as used crops or soil nutrient content and physical properties. For example, the use of mycorrhizae in the *Chenopodiaceae* and *Brassicaceae* families or in soils with the high available phosphorus content is irrelevant. On the other hand, the application by drip irrigation and their correct combination, which leads to a significant synergistic effect, significantly increases their effectiveness. This review can serve as a basic overview of the options available to vegetable growers that are currently available in the field of biostimulants.

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DEVELOPMENT AND CHANGES IN ECOLOGICIAL STABILITY OF RURAL LANDSCAPE

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Abstract

The country landscape has undergone transformations over the last decades that have affected both- its visual and functional side. The natural development of the society and the interventions of the political regime brought significant changes in the landscape structure, which also had an impact on the ecological stability of the landscape. The contribution analyzes the representation and the size of landscape elements in the landscape structure of the cadastral territory of the municipality Jelšovce in time horizons capturing the state of the landscape before the collectivization and current state. Within the given time horizons, the coefficient of ecological stability of the selected area (CES) is expressed. By evaluating the CES, where value of 1 represents a landscape with very low ecological stability and a value of 5 the opposite– a landscape with very high ecological stability, it is possible to observe how the country has been weakened, while drawing out measures aimed at enhancing the current ecological stability.

Keywords: countryside, ecological stability, landscape structure

Introduction

The landscape, its appearance and structure reflect long-term human activity. In the past, the rural landscape in the territory of today's Nitra self-governing region was mainly an agricultural landscape, human activity was developed in accordance with natural conditions, the biological balance was not substantially disturbed. Arable land in the form of narrow plate fields, vineyards towering in exposed places above villages, meadows and pastures, forests and its fragments, natural water courses and areas provided a certain level of ecological stability to the environment (Boltižiar, Olah; 2009).

The change was brought about by the socialist regime, under which the construction of agricultural areas, land consolidation and the creation of large-block fields where monocultures were grown was carried out. Plowing the balks, winding down meadows, riparian vegetation, intensifying agriculture, along with hydromelioration measures have led to a disruption of ecological stability (Izakovičová, 2012).

Today's landscape bears the mark of the past and adapts to the needs of the present. Unfortunately, it is often approached inappropriately as an inexhaustible resource. As a result of urbanization, not only urban but also rural settlements expand, fertile arable land falls victim to the construction of new suburban units or industrial sites, the country loses its identity (Salašová, 2012). There are changes not only in the area of individual elements of the current landscape structure, but also in the change of their use, which changes the functional and aesthetic value of the country. The question is to what extent these changes affect the environmental stability of the environment.

Material and methods

Characteristics of the area of interest

The subject of the research is the cadastral territory of the village of Jelšovce, located in the Nitra District, in the Nitra Region. Distance from the city of Nitra is 17 km, from the southwest side the area is adjacent to the village Čakajovce, from the northwest side it neighbours on the village Šurianky, from the north there is village Ľudovítová, towards the east there is the village Podhorany and from the southeast side is located village Dražovce. The municipality has 1,022 inhabitants (31 December 2017) and it is part of the Radošinka Local Action Group.

Jelšovce lies in the Danubian Lowland in the southeastern part of the Nitra Loess Hills and Nitra river flat. To the east of the area, there is the Tribeč mountain range with the Zobor mountain (588 m above sea level) and Žibrica (617 m above sea level). The cadastral area does not have a rugged character, it has a flat relief, the average altitude is 145 meters a. s. l. The cadastral area of the village is 1044 ha.

From the point of view of transport networks, the village has a convenient location, it lies on the route of the 1st class road No. 64, and connects the towns of Trenčín, Topoľčany, Nitra, Nové

Zámky and Komárno. The western part of the cadastral area is crossed by railway no.140 / Nové Zámky - Nitra - Topoľčany - Prievidza / with connection to the line No.141 / Nitra - Leopoldov /.

The axis of the village is formed by the aforementioned road of the first class, the river Nitra flows across the residential area of the village, on which the Jelšovce waterworks is located. Near the waterworks there are ponds that are surrounded by vegetation. According to the Atlas of the Slovak Republic, the original vegetation is represented by oak and cereal-oak forests, ash-oak-forests in large river basins (hard floodplain forests) and lowland hygrophilous oak-hornbeam forests.

In the past, the Jelšovce population was devoted to beekeeping, livestock farming, or viticulture, but agriculture was the most important component of livelihood. Even today, there are fertile soils in the vicinity of the village (chernozem, luvisols).

Figure 1 Jelšovce (source: http://www.jelsovce.sk/typo3temp/pics/85a3054ffe.jpg)

<u>Dendrological composition of the area of interest</u>

In the residential area of the village are represented point, line and area vegetation. There are 48 species of trees in public, semi-public and reserved areas, of which more than half are 54% autochthonous, the remaining 46% are allochthonous. The most common species is *Tilia cordata* (62pcs) at various age stages, followed by *Platycladus orientalis* (18pcs), *Pinus sylvestris* (17pcs), *Thuja occidentalis* 'Emerald' (16pcs) along with *Acer pseudoplatanus* (16pcs). The green area with the most important ecostabilizing effect is the Šibeje Park, located on the south-eastern border of the residential area. Major greenery is contained mainly in the area of the school, kindergarten, or cemetery. The municipality has been initiative in the matter of increasing greenery over the last 10 years, in addition to the revitalization of the Šibeje park, the village has also established a micro park, or an alley flanking the side road, which is supposed to connect the park into the countryside via the Šibeje park. It is positive that most of the young-planted trees are perspective and correspond to the rural environment.

The village's rural area is mainly made up of agricultural land, but the woody vegetation, which is represented in point, line and group form, is also an important landscaping component. In connection with the construction of the Jaguar Land Rover automobile factory and the expansion of the Nitra-North industrial park, Dolné Hony, the watercourse dam was modified to eliminate the risk of flooding the industrial site. In these dam modifications, the existing woody vegetation was removed, mainly *Salix alba*, *Salix fragilis*, *Populus* x *canadensis*, *Populus alba*. A new planting of these species was established after the bank was modified. The ability of new individuals to cope with adverse conditions (extreme weather conditions, lack of maintenance) and their long-term perspective is preliminary- the real impact can only be assessed in a few years‘ time. However, the shrubbery vegetation in the river bed and the river-herbaceous vegetation lining up the river have recovered and thrived. Line planting is also located along the field roads connecting the neighboring municipalities. There are species *Aesculus hippocastanum* and *Populus nigra*. Group greenery in the form of deciduous forest fragments is located in the immediate vicinity of the dead river channel of the Nitra river and near the Dobrotka stream. In particular, *Salix alba*, *Fraxinus excelsior*, *Populus alba, Alnus glutinosa, Negundo aceroides, Robinia pseudoacacia, Prunsu padus, Acer campestre, Sambucus nigra, Rosa canina, Prunus spinosa, or Prunus insititia* are represented.

Coefficient of Ecological Stability (CES)

Ecological stability is a term that is defined as the ability of ecosystems to persist even under the influence of disturbance, to preserve and reproduce their essential characteristics even under conditions of disruption from the outside (Míchal, 1992). The issue of determining the level of ecological stability of a selected area is addressed by several authors (Míchal, 1982; Löw et al., 1984; Muchová et al., 2009). The individual methodological procedures are based on the calculation of the Coefficient of Ecological Stability (CES), which represents a numerical value on the basis of which the country is classified into a certain degree of ecological stability. In the past, CES was more of an academic interest, however, it has now become an important practical element in designing land rehabilitation and development measures. The methodology for calculating the CES according to Reháčková, Pauditová (2007), is the result of the current scientific and practical experience, is based on the results of the mapping of the current landscape structure (CLS) and the current vegetation, taking into account the total area of individual types of landscape structure and their degree of ecological stability, based on work of Löw (1984), but supplemented by other elements of CLS, for these reasons, it was applied to the area of interest.

$$KES = \sum_{1}^{n} \times \frac{pi \times Si}{p}$$

Equation 1 calculation of CES (Reháčková, Pauditšová; 2007)

CES – coefficient of ecological stability of the area of interest

pi – total area of individual types of landscape structure elements (ha)

Si – degree of ecological stability

p – total area (ha)

n – number of elements of the landscape structure in the area of interest

Based on the calculated CES, we classify the landscape to 5 degrees of ecological stability, ranging from "landscape with very low ecological stability" to "landscape with very high ecological stability". Each stage of ecological stability is accompanied by a proposal for framework measures to increase or decrease preserving the landscape's ecological stability.

Table 1 Interpretation of coefficient and degree of ecological stability (Reháčková, Pauditšová, 2007)

Landscape evaluation	CES	Ecological stability degree	Measures
landscape with very low ecological stability	1,00 – 1,49	1	high need for new ecostabilization elements and ecostabilization management measures
landscape with low ecological stability	1,50 – 2,49	2	the need to implement new ecostabilizing elements and ecostabilizing management measures
landscape with average ecological stability	2,50 – 3,49	3	conditional need for realization of new ecostabilizing elements, resp. application of appropriate management measures
landscape with high ecological stability	3,50 – 4,49	4	implementation of appropriate management measures
landscape with high ecological stability	4,50 – 5,00	5	implementation of maintenance management

The aim of the paper is to determine the ecological stability coefficient according to the given formula in selected time horizons and by their comparison to describe the development of the landscape space in terms of ecological stability.

The first time horizon is the range of years 1950-55, when the first ortographic photo took place on the solved area, and a topographic map was prepared at the same time. The second reference period is the year 2017, i.e. the present, when a larger number of map data, as well as a better orthographic photo are available and is thus more accurate than in the first reference period. Based on the data, the total area of individual types of landscape structure elements represented in the given area was determined, and according to the table contained in the CES methodology, the degree of ecological stability was assigned to it, then the ecological stability coefficient was determined.

Results and discussion

Level of ecological stability and CES in 1950-55

On the background of the 1950-55 period, the landscape space is captured before collectivization.

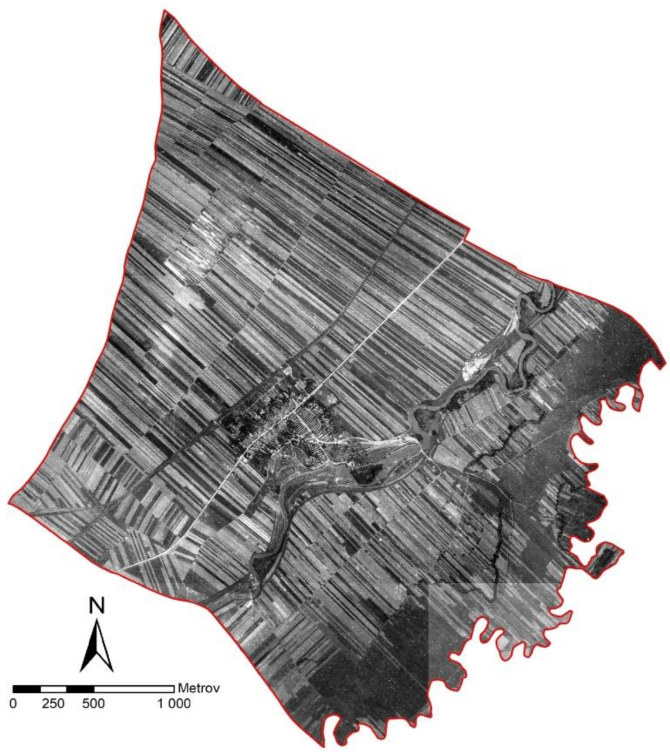

Figure 2 Ortographic photo- Jelšovce 1950-55 (© GEODIS SLOVAKIA, s.r.o. a Historické LMS © Topografický ústav Banská Bystrica.)

On the orthographic photo, there is a clearly readable mosaic of plate fields of the unregulated meandering river bed of the Nitra River. A considerable area of grasslands is located in the eastern part of the cadastral area. The residence itself is not too large, the dwellings are arranged perpendicular to the main and one side road - the village is further branched towards the Nitra River. In this period, houses have a longitudinal shape, they are located on the boundary of the plot, behind the land there are barns and gardens connecting the village with the landscape. Public and semi-public greenery is represented in the form of space and a garden belonging to the church, football field and its adjacent greenery and cemeteries. Vineyards located in the western part of the residential part of the village are also a significant part of the landscape structure.

Table 2 Areas of individual types of landscape structure elements represented in a given territory between the years 1950-55, their percentage and the corresponding degree of ecological stability.

CLS element / actual vegetation	**Corresponding degree of ecological stability 1950-55**	**Total area of the landscape structure element 1950-55 (ha)**	**Total area of the landscape structure element 1950-55 (%)**
Fields	2	792,24	75,9
Grasslands	3	161,90	15,5
Gardens	2	24,49	2,3
Woody vegetation	3	23,94	2,3
Water areas and streams	5	15,17	1,5
Built-up areas	0	14,48	1,4
Vineyards	2	11,28	1,1
Cemeteries	2	0,98	0,1
Unused areas	2	0,00	0,0
Allotment gardens	x	0,00	0,0
	Total area (ha):	1044	

Based on the data obtained, the value of the ecological stability coefficient in the Jelšovce area was set at 2,19 in 1950-55, the degree of ecological stability corresponds to the value 2, which represents a landscape with low ecological stability. The value of CES is relatively low due to the high share of arable land, which consists of three quarters of the cadastral area of the solved rural settlement. The second largest area is occupied by grasslands (15,5%). Although they are assigned a degree of ecological stability 3, the area is not sufficient to improve the CES value. Similarly, there is a woody vegetation whose level of ecological stability is also 3, but it occupies a negligible amount of area – 2,3%. The most ecologically stable element is the natural watercourses in the form of the river Nitra and the stream Dobrotka, which, however, represent only 1,5% of the area of interest. The landscape captured in the years 1950-55 required the realization of new ecostabilization elements and measures, but the following interventions further weakened ecological stability.

Level of ecological stability and CES in 2017

At present, the landscape structure is different from that of the first reference period. In particular, the size of the fields increased at the expense of grasslands. The Nitra River is regulated, dead river channels as natural remnants are surrounded by woody vegetation. There is the Jelšovce waterworks on the river Nitra, the beginnings of its construction are already visible on orthographic photo from 1955. In the northeastern part, in close relation to the residential area, there is also an agricultural area with a considerable territory, which was created in the 80's of the last century . In the same period, according to the municipal chronicle, the vineyards, which, like meadows and pastures, gave way to arable land and were destroyed as well.

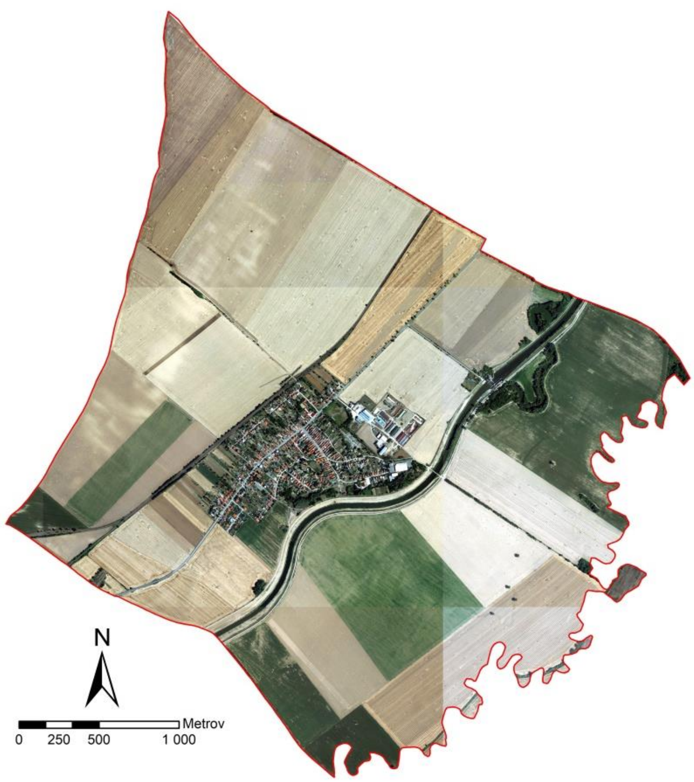

Figure 3 Ortographic photo- Jelšovce 2017 (© EUROSENSE, s.r.o. a GEODIS SLOVAKIA, s.r.o.)

The municipality has grown, the number of plots with family houses has been increasing to a greater or lesser degree from all sides. The form of family houses is mixed, in the village you can find traditional elongated houses described above, houses of square to slightly rectangular basement with saddle and flat roofs from the second half of the 20th century as well as the current "catalog" architecture, which is mainly concentrated in the suburban unit located in southeastern part of the village, which was attached the village at the beginning of the 21st century. Public and semi-public green areas in the village have remained relatively well preserved compared to the past, while the Šibeje Park, located between the residential area and the Nitra River, forms a significant area of public greenery. The park has a natural character and is composed of woody vegetation and open grassy part. Through the accompanying vegetation of the river Nitra it links the residential areas with the rural part of the village.

Table 3 Areas of individual types of landscape structure elements represented in a given territory in 2017, their percentage and the corresponding degree of ecological stability.

CLS element / actual vegetation	Corresponding degree of ecological stability 2017	Total area of the landscape structure element 2017 (ha)	Total area of the landscape structure element 2017 (%)
Fields	1	882,57	84,5
Gardens	1	47,61	4,6
Woody vegetation	3	34,36	3,3
Grasslands	3	31,81	3,0
Built-up areas	0	29,38	2,8
Water areas and streams	2	13,35	1,3
Unused areas	2	3,06	0,3
Cemeteries	2	1,33	0,1
Allotment gardens	2	0,53	0,1
Vineyards	x	0,00	0,0
	Total area (ha):	1044	

Based on the data obtained, CES = 1,12 was determined, it is a country with very low ecological stability, where there is a high need to implement new ecostabilization elements and ecostabilization management measures. As in the first reference period at a low level of CES, a high proportion of fields (up to 84,5%) and a low proportion of elements with a high degree of ecological stability (woody vegetation – 3,3%; grasslands - 3%). Elements with an ecostabilizing function need to be added to the landscape. When designing elements of woody vegetation, it is necessary to create or supplement the vegetation structure, which is able to ensure not only ecological stability but also anti-erosion protection and visual quality of the landscape.

Conclusions

The paper deals with the calculation of the ecological stability coefficient (CES) of the cadastral area of Jelšovce before the collectivization period and in its current form. In the two reference periods, for the calculation of the CES, the areas of the individual elements of the landscape structure and the total area were identified, the degree of ecological stability were assigned. The selected municipality-Jelšovce is historically linked to agricultural activity, therefore a high proportion of arable land is justified. While in the years 1950-55 the fields occupied 75,9% of the total cadastral area, in 2017 the area increased to 84,5%. Since the characted of the fields is distant to the nature, their degree of ecological stability is 1, which in combination with the large area significantly affects the resulting CES. In 1950-55, the Jelšovce area was categorized as a "landscape with low ecological stability" with a CES value of 2,1. In the second reference period the ecolocigal stability has worsened, scoring value of 1,12 – „landscape with very low ecological stability". By strengthening and creating a network of elements that have an ecostabilizing effect in the country combined with appropriate agro-technical practices, this situation can be improved and the level of ecological stability stabilized at a more favorable value.

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A MULTI-CRITERIA ASSESSMENT OF THE OPEN UNIVERSITY CAMPUS

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Abstract

We often regard university campuses as an element that has character of a public or semi-public space. If it is located in an urbanized city structure, it is its important part. In urban area, it forms significant spatial, social, economic, visual and health functions. It is a partial component of green infrastructure and its quality also influence the quality of the surrounding environment. The article focuses on presentation of the methodology of multi-criteria evaluation of the quality of university campuses and their potential. The contribution aims on the topic of university campuses and as well on connection between the architectural style of social realism popularized in the totalitarian regime and today's modern urbanized environment of the settlement, to preserve the idea of a sustainable complex. The methodology tries to include all static and timeless elements of university campus quality (mobility, stay, accessibility, security, equipment, human scale and quality perceived by different senses). The methodology consists of several attributes within each rating category, which are accompanied by a detailed manual. Each description of attribute is intended to eliminate variations in results because the assessment is based on the subjective perception of space. Therefore, the characteristic of each element being evaluated is simply and clearly described with clear reference to the issue. The article further reflects the results from a specific university campus of the Slovak University of Agriculture in Nitra, through evaluation sheets, graphs and other different space analyses. The main objective of the thesis is to present this model of methodology, because this part of the university campus design process is very important. Only after thorough analyses and detailed assessment we can name the individual problems of the complex and choose the most suitable solution.

Keywords: university campus, open space, public space, green infrastructure, sustainable architecture

Introduction

The period of totalitarianism is perhaps the most dramatic not only in the history of Slovakia, but also in all countries of Eastern Europe. This primarily concerned architecture. Studies of totalitarian architecture and even today in European countries are isolated, often based not on art studies, but on political grounds. Nevertheless, the building of the Slovak University of Agriculture in Nitra is proof that quality architecture exists during this period. Extraordinary architectural works can be created even in undemocratic social conditions.

„Slovakia has changed its appearance in five years. Once upon a time it was poor and beautiful, today it is beautiful and rich.“ (Žiak, 1954, In: 81st Meeting of the Czechoslovak People´s Party)
In “Gottwald's first five-years” (1949-1954), besides the massive industrialization of Slovakia and the gradual construction of flats, the construction of schools, kindergartens, hospitals, major cultural buildings, universities and university campuses continued. These are in today's world of continuous rupture of important building icons need to be protected and exploited - to bring them "life". Otherwise, objects lose what they have identified, what personifies their architecture. They lose the link to the author and the details that represented their history and ensure their functional capability. Also historical landscape structures show to us very close relationship between a human being and the landscape (Kristiánová, 2013). Unlike many industrialization factories, which left only empty construction, reinforced concrete or masonry colossuses without any function, the campuses have at least maintained their functionality and continue to be used for several years for the purpose for which they were built. In addition, the inter-zone areas create public or semi-public spaces, which are still used by employees, students, or bystanders. A gradual process of restoring every public, semi-public, or private space is preceded by a set of detailed analyses. At the analysis stage, several processes are being applied, the polyvalidity of which is being examined. One of the processes is subjective criticism on the basis of different evaluation criteria, but another relevant view of monument care, which perceives architectural works as a legacy of the past, enters into the evaluation process, focusing on those sites that are related to remembrance (Moravčíková et al., 2013). In case of this issue, it is necessary to deal with existing methods, but also to bring new methods into the process of exploring university campuses. One of them is conceptual thinking. It is

essential not only to develop a plan for a constructed environment, but even more for understand future opportunities and threats. In this regard - perhaps more than in the past - the process of creation has become a survey process, a process of exploring new spatial possibilities and exploring new methodological approaches (Rosemann, 2008). Based on such conceptual thinking - design thinking, the "Research by design" method will convey various aspects on the basis of which we can draw a relevant result from the design process by proving the methodology in practice.

Material and methods

The object of interest is the complex of the Slovak University of Agriculture in Nitra (SUA). The university campus is situated on a flat terrain on the left side of riverfront about 250 meters away from the Nitra River. In the northwest of the complex is bridge, which connects east-west axis formed by “Štúrova” Street and “Andrej Hlinka” Street. The area of the complex is delimited from the north by “Andrej Hlinka” Street, which turns to northeast from the bridge, from the west is delimited by “Nábrežie mládeže” street and from the east by built-up area of “Akademická” street. Area of the Slovak University of Agriculture is bounded by area of “Agrokomplex” exhibition from the south and partially from east side.

Figure 1 Localisation of the campus within Nitra (Čibik, 2019)

The SUA complex is adjacent to several buildings and areas with urban, but also metropolitan importance. Behind the river Nitra there is a historical villas part of city centrum and the building of university dormitory – Mladosť, which was built before the original university complex (south from the "Štúrova" street) was made (Szalay et al. 2013). From the west side adjoins the building of Constantine the Philosopher University - it was built as a faculty of education shortly after the building of SUA and settlement "Chrenová", which were projected at the same time as the campus.

The original SUA complex is a major building block in the urban composition of the city. Szalay et al. (2015) says that the complex forms the city's silhouette. They said the proposal was to declare the property as a national cultural heritage. Rector´s building – pavilion E together with hall´s curve situated to main east-west historical axis compositionally follows object of dormitory "Mladosť" on the right side of the Nitra river and also silhouette of historical city – urban dominants - Piarist´s church tower and Nitra´s castle. The original University campus stands in open air surrounded by park´s greenery. The individual objects of the whole area are randomly placed on the land. The main group of pavilions of the university is composed perpendicularly to city axis and it ends the view from the city. The other pavilions are located to the east and south of the main block. There is a botanical garden with a water surface in the northeast part of the complex.

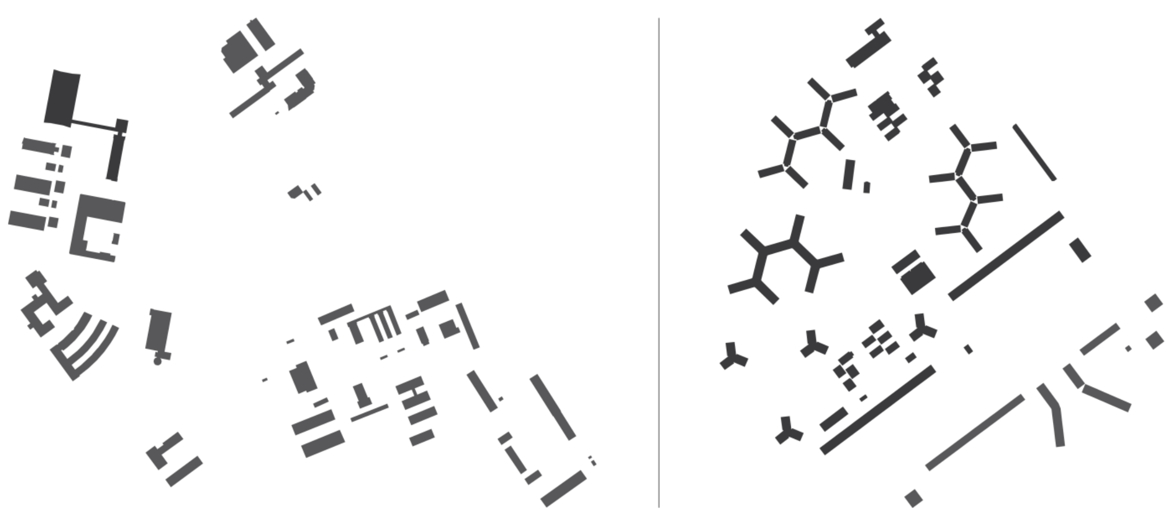

Figure 2 The site plan of buildings forming the university (on the left). The site plan of the settlement "Chrenová", which were projected at the same time as the solved campus (on the right) (Čibik, 2019)

The area is very important for users - the students, employees and the guests of the university, but it is also an important public area of the city and an integral part of the environment used by residents and visitors of the “Agrokomplex” exhibition. Not only as a functional transit area and connection to the city centre with the large residential area - zone “Chrenová I. - IV.”, but also as a recreational background (spaces for children, botanical garden and other attractions). The perfect background of the area is made up of objects included in the National Cultural Monument. This is the reason for improving the conditions and creating a comfortable environment.

<u>The Methodology of a multi-criteria assessment</u>

The methodology was developed on the basis of two freely available publications and it is a combination of two methodologies that have been verified in practice. One of them is the publication of the city of Hlohovec, which was elaborated within the strategic policy of the city - “The Concept of Public Space Hlohovec” (Lukačovič et al. 2016). The methodology of public space evaluation itself was created during the "workshop" led by Ing. arch. Adam Lukačovič. The second publication is “Methodology of Square Quality Evaluation” (Kilnarová et al. 2014). Both methodologies were processed into one, changing the hierarchy, division, and naming of some attributes. Subsequently, they were enriched with attributes that directly relate to university campus as well as student or university staff needs. Both of the above-mentioned methods of public space assessment are based on Gehl's public space methodology (2013). Danish architect Jan Gehl's methodology is based on three stages: first life, then space and third buildings. This thought process in the stage of public space creation will ensure the highest standard in the development of urban space. How should an ideal university campus look like and how to characterize criteria that testify to its quality? The methodology seeks to incorporate all the static and relatively constant elements of the quality of university campuses (the possibility of movement, availability, security, human scale and quality perceived by various senses) (Gehl, 2013).

Evaluation criteria: Type of the university campus, 4 categories/20 subcategories

- CD – Complexly designed area (The area where the main university building is located, student homes, library, student hospitality, scientific workplaces, meeting rooms, cafes, sports fields, smaller parks and so on)

- PD – Partially designed campus (University, student homes, library, sports fields, scientific workplaces, greenery)
- SA – Sufficient area (University, student homes, scientific workplaces, library)
- IA – Insufficient area (The campus where the university is located and at least one of the above elements)

A_Category /space around/

The title "university campus" names who the space is intended for. Within the character of the surrounding development there are discussions about semi-public or semi-private space, but the result is always a collective space that should guarantee comfortable use for all groups of population, regardless of age, social or cultural background and regardless of handicap.

1. Space for education and obtaining information – Library, cafés, study rooms, studios or similar social spaces where the student can work independently or in groups on assignments and projects or acquire knowledge within a team.
2. Space for rest and sleep – Dormitories, overnight stays, student homes, student flats, lofts or other accommodation facilities for students and outside staff, providing comfortable rest and sleep.
3. Space for the culture and sport – Meeting rooms, club rooms, TV rooms, free time activities, music, theatrical films, sports fields, playgrounds, grass areas with maintained grassland, multifunctional areas.
4. Space to deepen the socio-economic dimension – Cafés, pubs, music clubs, disco clubs, bars. Basically, all the attributes that we could also classify into category 3, but they also show a profit.
5. Space for eating and drink – Dormitory canteen, fast food restaurants, restaurants, brunch´s, buffets, barbecue grills with open fire.

B_Category /dynamic and station motion/

People move within the city because of the inevitable activities, eg. for work, shopping, for services, for rest, or voluntarily. Making this movement more pleasant is possible by increasing perceptual quality. Security, freedom, simplicity, sensual richness are signs of quality movement. A higher level of interaction with the environment must also be a priority for communications with a primary traffic function. Cities must primarily allow people to move around.

1. Opportunity to walk - One of the basic requirements in a people friendly area is to allow comfortable pedestrian movement. Quality walking should be safe and free. The assessment focuses on dimensions of pavement and quality of their surfaces, but also monitors whether pedestrians have obstacles in the way, such as stairs, street traffic, or improperly placed furniture such as benches, litter bins, public lighting columns and parking cars.
2. Opportunity to stand - In addition to a comfortable walk, the campus should also allow people to stop. First of all, enough space is needed so that standing people do not block pedestrians from moving. The ideal stopping places offer a view of the back-covered area.
3. Opportunity to sit - In the case of the city furniture, which is primarily designed for seating (for instance benches), it is important in addition to its own presence to position (preferably with a covered back and undisturbed view), to make comfort and suitability of used materials (using of materials such as metal, concrete or stone on the bench parts is inappropriate for person touching). It is pleasant if the layout of the furniture offers different seating options for individuals, couples and larger groups. The possibility of sitting up improves the presence of walls, posts and stairs - elements that primarily serve a different purpose, but can be seated on them. It is a secondary seating. The presence of restaurant terraces is also being evaluated, and they are also strongly involved in the social life of the area.
4. Availability, permeability – Short distances are the privileges of a compact city. These help to quality and active use of public spaces. Transparency and orientation in space is supported by hierarchy.
5. Parking – Every public or semi-public, but also private space needs parking places, which are mostly governed by a decree. For the university campus, we can only follow the decree for accommodation facilities, student homes that provide parking. However, if the main university building belongs to a campus, it has to offer parking places to employees and not just students. However, with the modern trend of bicycle paths and green universities, it is necessary to consider whether there are enough bicycle parking stands in the area.

C_Category /safety/

Feeling safety is one of the basic preconditions for quality of life. On the one hand, it is traffic safety and on the other hand social. The prerequisite for both is visual clarity of space and social control.

1. Social safety - The feeling of danger in public space is not only caused by transport, but also by fear of crime. The presence of a large number of people and related social control itself has a comparable impact to the presence of camera systems or patrol officers. It is important that the space is live all day long, on weekdays and weekends. The features of the surrounding area should be varied - to provide either housing and job opportunities or civic amenities. This will ensure that the area is not abandoned during the day. The sense of security is also aided by the transparency of the space and its sufficient illumination after dark. If social control is inadequate, signs of vandalism may occur.
2. Traffic safety - Good transport accessibility has an impact on the liveliness of the area, but it also entails many risks. The most significant is the lack of safety of pedestrians or cyclists due to stronger participants in transport. The transport solution should respect the following order of precedence: security, public space, pedestrians, cyclists, public urban transport, service transport, individual transport and parking.
3. Safety in sport and entertainment - If sports facilities are located on some premises, they must comply with the applicable standards for the construction of such facilities.
4. Healthy environment - People tend to spend their free time in nature in terms of a healthy environment. Cleanliness of air, minimizing noise, a pleasant climate, lightness or protection from wind should not be just a privilege of parks. Environmental ecology must be maximized at every point of the city.
5. Communicability - The public space value must be clear at first sight. Space use supports information, orientation in space, sensory and cognitive perceptions.

D_Category /area aesthetics/

Ergonomic and sensational comfort is the prerequisite for a quality of the space. Sufficient sensory and cognitive variability of environment is a measure of attractiveness.

1. Total visual identity - Human perceives most of the information through sight. Therefore, the visual quality of university campuses has a significant impact on the impression of space. The closeness of the square and its clear boundaries, but also the quality of the

architecture are evaluated from the perspective of urbanism. The positive point is the presence of a distinctive landmark (such as the university's main building), which can be a hallmark of a particular space and thus facilitate space orientation. Not less important are small stimuli that pedestrians perceive at eye level. The artworks, the quality of parter's details (such as bossage, sgraffito, interesting texture), the quality of the materials used in the parterre and the design of the street furniture are also evaluated. The overall impression may also be negatively affected by clutter, lashes (unstoppable places where houses should stand), large numbers of parking cars or aggressive, tasteless advertising.

2. Auditory feel of the area - Another important attribute which is perceived by people is hearing. Rather, it only helps to illustrate the image of the area, but in some cases (usually the cause of heavy traffic); a large noise load may be a limiting factor that prevents more active use of the area.
3. Greenery – One of the most important attributes of university campus assessment is greenery. There is no doubt about the environmental and ecological efficiency of greenery in relation to its ability to regulate water economically, to positively influence climatic conditions or to cultivate the environment. Greenery should not be evaluated only by the methodology based on quantity, but mainly on the quality of individual trees, bushes, herbaceous stands, grasslands and others.
4. Water and water elements – Water is also one of the more important attributes of university campus assessment. Water and water elements, which are subjectively evaluated by this method based on quantity but mainly on the quality of individual elements.
5. Human scale – Spaces must be human-friendly, pedestrian-friendly. We consider smaller-scale elements, more accessible to people. The scale of the city or municipality in which the campus is located must return to human dimensions.

<u>Field researching part</u>

One of the results that we want to achieve in the long term is to verify the methodology in practice. For evaluation we chose the already mentioned campus of the Slovak University of Agriculture in Nitra. Research was conducted in winter and summer semesters on a sample of 74 students. Students were informed in advance about the methodology and about the fact that it is a subjective assessment. The evaluation process was carried out under authors of the methodology. We divided the area into smaller parts and we gradually allocated points to individual attributes within 4 categories. Each attribute was rated from 0 to 5. Points or grades were entered in the ranking sheet. The results were collected and evaluated after the process.

Results and discussion

After averaging the results, we conclude that the area has negatives elements, but it also has enormous potential, which with we can count in the future. On the following chart, which was created by averaging all attributes and their points, we can see that the area has quality greenery, water elements, but also a whole environment in global. On the other hand, the complex is lacking in communicativeness, better exterior furniture, or pavements. There are no pubs, cafes, or other components of extending the socio-economic dimension. It is interesting to note that even though massive elements of green and water situated in the area, the overall visual identity has been assessed by an average mark. Consequently, even small deficiencies and negative solutions can significantly affect the appearance of the premises.

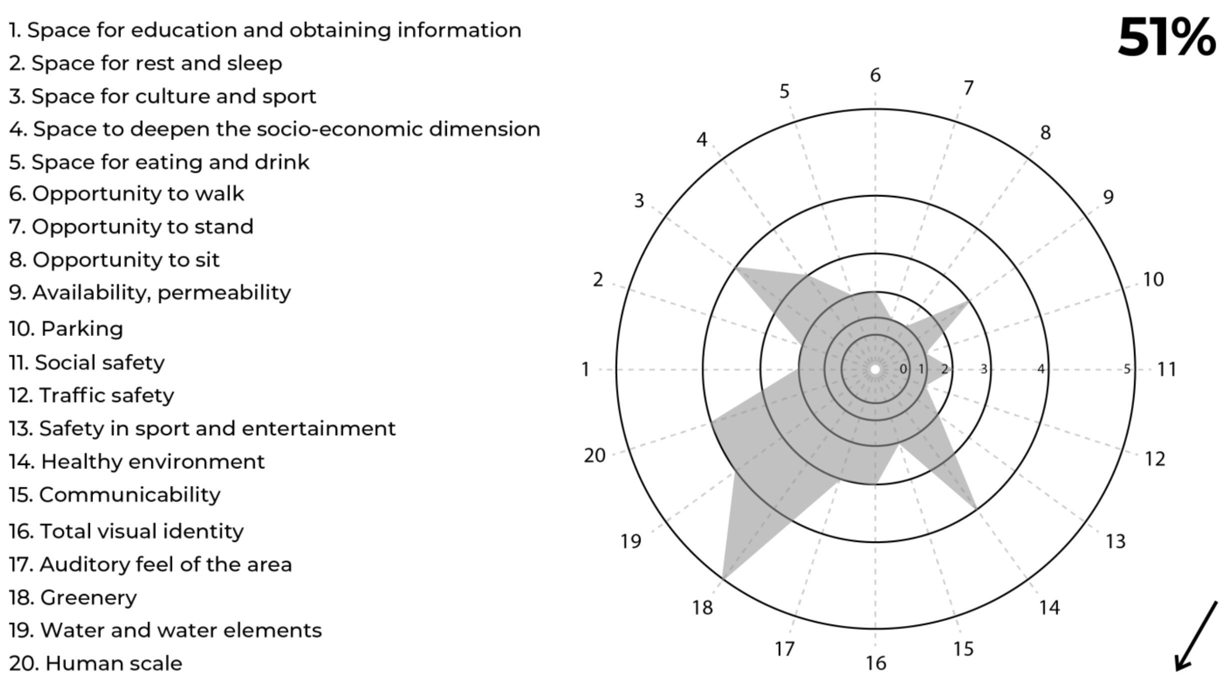

Figure 3 A multi-criteria rating graph with named attributes (0-5) and evaluation results (Čibik, 2019)

Conclusion

The campus of the Slovak University of Agriculture in Nitra does not represent current requirements of visitors who spend time here, but also the people who pass through it, even though it is a significant spatial and functional dominant of Nitra. Due to the fact that this space is used not only by students, but also by the inhabitants of the city, it is necessary to solve it comprehensively, in relation to current trends in landscape architecture and architecture. However, all smaller or larger interventions need to be addressed with regard to the architectural style made by the author of the original project. The result should be a multifunctional university, but also a public space that meets all the requirements of a quality and functional campus. Positives, with which we can count in the future, are clearly the location of the solved area and very nice surroundings. Nearby, there are many important and attractive space-forming elements that are part of the urbanized environment and fit perfectly into the potential restored university campus. They are mainly: botanical garden, but also a smaller park in front of the student dormitory. After evaluating the results and thoroughly analysing the values of the university campus, it is desirable to transform the campus into a social and cultural node as the focal point of the surrounding urban space.

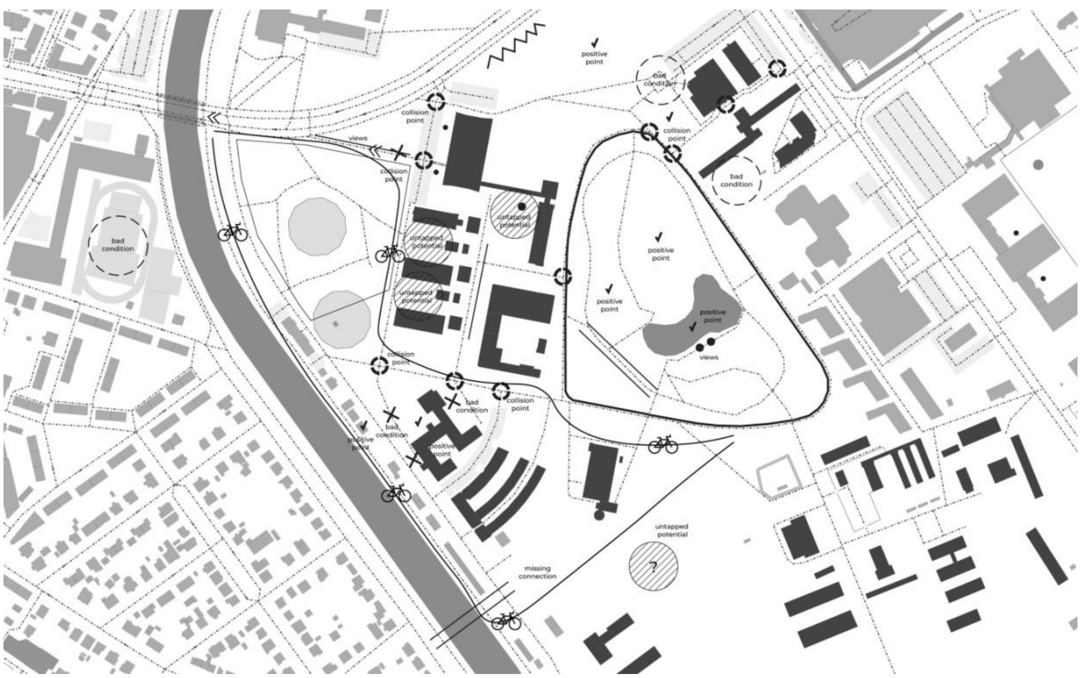

Figure 4 An illustration of the analytical site plan (problems, positives, negatives, views) (Čibik, 2019)

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EVALUATION OF THE RESULTS OF MEASUREMENTS AND MONITORING OF THE ŽILINA DAM

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Abstract

Žilina Dam is located on the outskirts of the locality gallows. It began to be constructed at the end of year 1994. The water reservoir serves as a water supply for the operation of the hydroelectric power plant and serves as part of the flood protection on the Váh River. Geodetic measurements of vertical and horizontal movements of the dam are as network of observed reference and elevation points - 6 associated reference points and 2 points of the alignment network. All reference altitude points show steady vertical displacement values. At present time, the changes in vertical and horizontal displacements are no longer large. The total value of the shifts since the beginning of the measurements is higher, but is based on the consolidation of the dam materials after filling the dam. Today, stabilization is now complete and the dam is stable, and shifts do not indicate a problem with the stability of the dam.

Keywords: Geodetic measurement, Žilina dam, monitoring

Introduction

Žilina dam is located on the town part with the name Šibenice. The main purpose of the construction of the dam was to use the water flow to produce electricity. In addition to this main purpose, the construction also fulfils many other important tasks: the remediation of the active landslides of the Dubeň massif, the protection of the town of Žilina before 100 and 1000 years of water, recreational and sports facilities for the Žilina region, the prospect of water transport ect.

The construction of the dam began in late 1994. During the construction and before filling the water reservoir, it was necessary to relocate the inhabitants of 150 houses, mostly from Mojšová Lúčky and Hruštín, to the newly built residences in Nová Mojšová Lúčka and in Rosinky, whose localities were chosen by the citizens themselves. The total agricultural land occupied for the reservoir is 272 ha of land III. and IV. quality class.

Parameters of the Žilina dam

The hydroelectric power plant - has two vertical Kaplan turbines, the diameter of the impeller is 4850 mm, the capacity of the turbines is 2x150 m3 / s, the average gradient to the turbines 24.1 m. Installed power total 62 MW. Annual production is 173 GWh of electricity. The first hydroelectric power plant was put into trial operation 17.12. 1997 and second aggregate 31.3. 1998th.

For the release of large waters, the triple-bed weir with a width of 3x12 m serves. The height of the segment is 11.4 m, the flaps are 3.3 m, the total height of the closure is 14.7 m. The shutters are hydraulically controlled.

The water reservoir serves as a water supply for the operation of the hydroelectric power plant and at the same time increases the energy gradient and thus the electricity production. The reservoir length is 7.5 km and its width is 250-600 m. The reservoir volume is 17.9 mil. m^3, storage volume is 8.0 mil. m^3. The maximum water level is 352.0 m above sea level.

Dyke of the reservoir **-** the width of the dyke crown with the communication is 9,5 m and 6,0 m, without communication 3,5 m, it is sealed with foil bound to the underground wall.

Geodetical measurement of shifting

The measurements of horizontal and vertical displacements on the reference and observed points of the Žilina waterworks are carried out by the employees of Vodohospodárska výstavba š.p. Bratislava, Department of Technical and Security Supervision (TBD), Department of Geodesy.

Accuracy of geodetic measurements is assessed according to standard ON 73 6807 "Observation and measurement on water works" and STN 73 0405 "Measurement of building objects displacements". To measure displacements and deformations on the waterworks Žilina, accuracy is required: height changes - on concrete and masonry objects mV max. is 1 mm, positional changes on concrete and masonry objects mX, Y can be max. 2 mm.

Measurements are made using the very accurate levelling (VPN) method. It is a geometric levelling from the center. Measurements were made in the Baltic system after levelling (Bpv). Leica LS15 digital levelling instruments, Leica DNA 003, invar code levelling lathes and the appropriate metering inventory were used for the measurement.

The Leica LS15 levelling device is characterized by a unit mean error of 0.2 mm/km and a Leica DNA 003 0.3 mm / km.

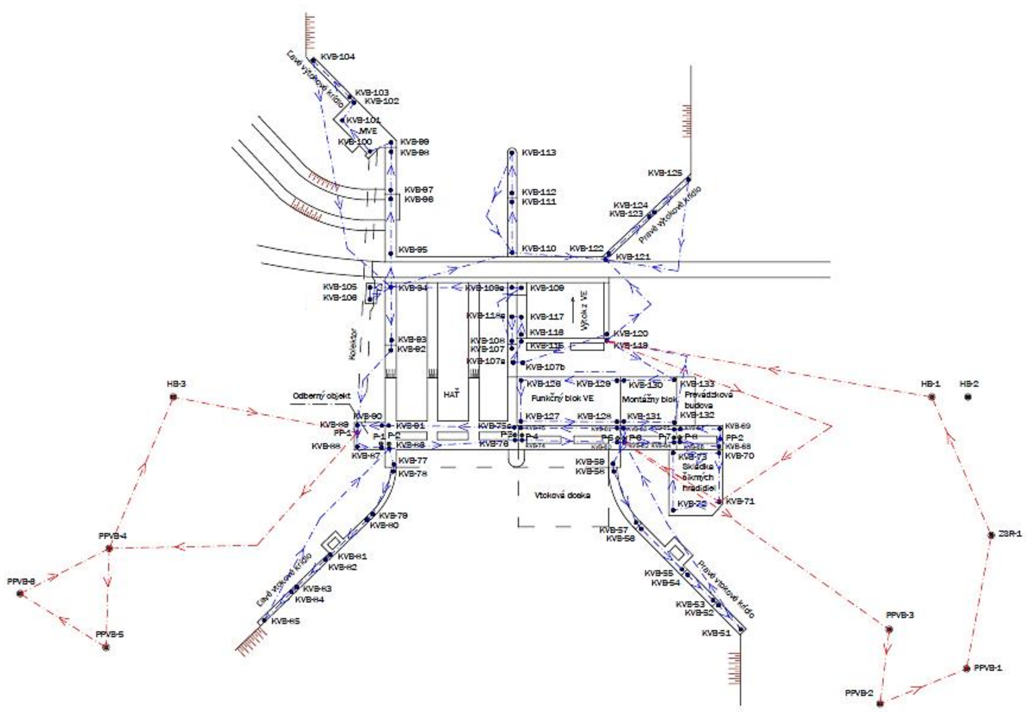

Figure 1 Network of reference points and observed for Hydro power plant

Measurement of vertical displacements at Hydroelectric Power Station

Measurements of vertical displacements began in February 1997. The baseline measurements were made before the dam reservoir was filled in September 1997. By September 2018, 52 stages of measurement had been performed. The measurement results were influenced by the course of building construction, water level in the reservoir, temperature and measurement accuracy.

The network of reference and observed elevation points on the Hydro Electric Node (Figure 1) currently consists of 6 composite reference points (PPVB-1 to PPVB- 6), 2 points of the alignment grid (HB-1 and HB-2), 1 composite point (ZSR-1), which was completed in 2012 in the construction of a railway near the waterworks, 82 observed altitude points (KVB-51 to KVB-133) at water power plant, weir and engine room buildings, 20 observed elevation points in the injection corridor (Figure 3) (KVB-1 to KVB) -17) and 25 observed altitude points on a small water power plant collector (Figure 2) (KVB-18a, KVB-18 to KVB-39).

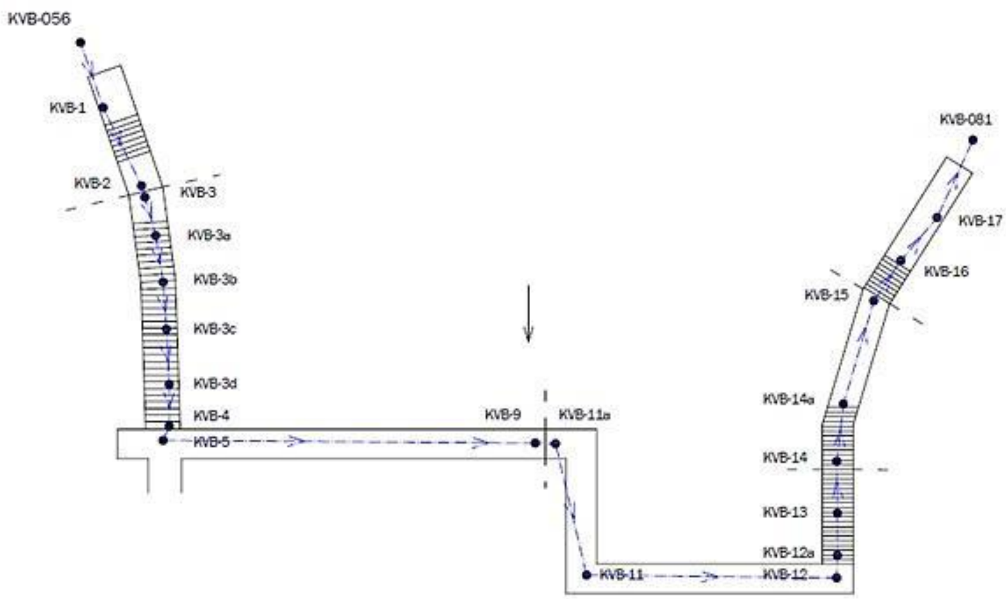

Figure 2 The deployment of the observed points in the injection corridor

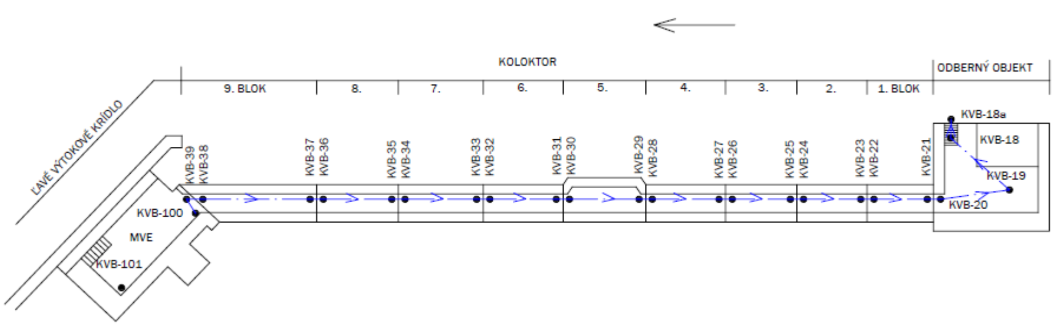

Figure 3 The deployment of the observed points in the collector

Measurement of vertical displacements on protective reservoir dykes

Reservoir dam dykes measurements (Figure 4) consist of measuring the left-hand and right-hand side of the dam. The left-hand dyke side consists of a network of 3 reference points (PPVB-4 to PPVB-6), 3 points of the stakeout network (HB-3, HB-35A, SCZ1991) and 6 observation points (KVB-1 to KVB-6). The right hand dyke side is made up of 8 reference points (PPVB-1 to PPVB-3, PVB-1 to PVB-6), 4 points of stakeout network (HVB-60A, HVB-78, HVB-78A, HVB-80), 18 points observed (KVB-7 to KVB-24) and 8 points on elevation boxes (VK-1 to VK-8).

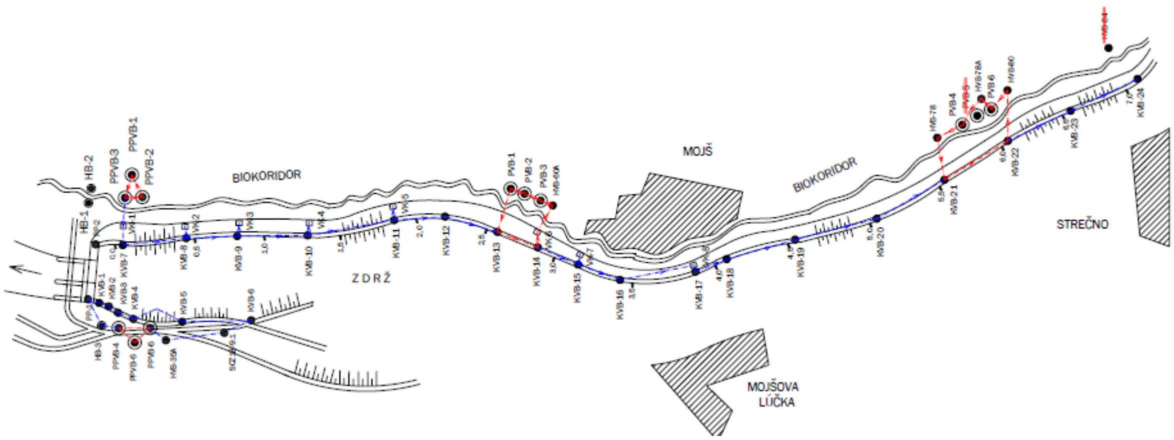

Figure 4 The deployment of the observed points at reservoir dykes

Measuring the horizontal displacement on the Hydro Power Plant node

The measurement of horizontal displacements (figure 5) started after the construction of reference and observed associated points in September 1997. Until September 2013, 41 measurements of horizontal displacements were made at Žilina dam. The positional network consists of 6 conjugate reference points (PPVB-1 to PPVB-6), 2 observed positional points on VE inlets (P-4 and P-5), 4 observed positional points on the hati (P-1 to P-3, PP-1), 4 observed position points on the dump gate for the VE and hollow (PP-2, P-6 to P-8) and 1 observed point on the right-hand dyke crown (KVB-7) Fig. 5. The horizontal displacements were measured locally in the coordinate system, the Y-axis of the coordinate system is parallel to the Zilina dam axis (connecting points P1, P2) and increases from left to right. The X axis is perpendicular to it and increases in the direction of the water flow. Measurements were made using the terrestrial method (measuring directions and lengths). The Nova Leica MS60 multistate and Leica reflecting prisms were used for measurement.

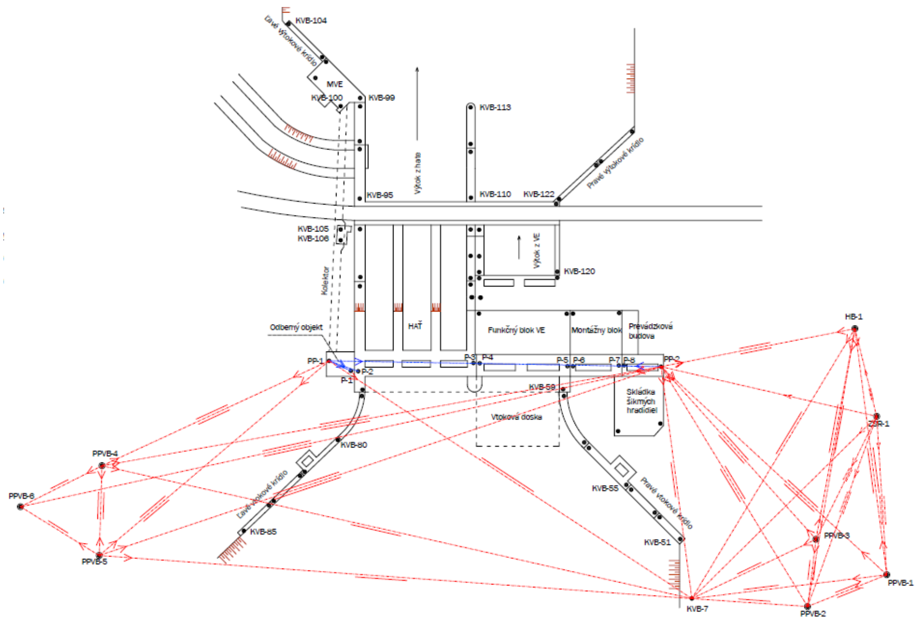

Figure 5 Network of conjugate reference points at Žilina dam

Measuring the hydropower plant inclination

Measuring the hydropower plant inclination is performed by the Zeiss PZL 100 optical weigher from the observation pillar with a centering plate mounted at a height of 322.30 m above sea level, the target point was placed at 354.00 m above sea level. The baseline measurement was made in December 1998. During the reporting period, until September 2018, 43 control measurements were performed.

The inclination value of the last 43rd control measurement was 0.25 mm in the water flow direction and 4.0 mm in the perpendicular direction. These values are within the elastic deformations of the object. The accuracy of the tilt so determined is determined by the accuracy of the Zeiss PZL 100, which is 1 mm / 100 m in length.

Processing of measurements

We performed the measurement processing separately for measuring vertical displacements and measuring horizontal displacements.

Processing of vertical displacement measurements

Processing of vertical displacement measurements it consisted of several steps. The data are processed in the program to offset the leveling software Leveling. The processing is based on an efficient and undefined estimation of the leveling network parameters generating optimal results in terms of the least squares method. The weight of the individual measured elevations was assigned based on the length of the leveling section. In balancing, a free network model was used, based on which the reference point heights are random variables and thus can be changed, while their inaccuracy is respected for the points determined. After calculating the altitudes of the points and their accuracy characteristics, the calculation of vertical displacements between individual stage measurements was performed in Microsoft Excel.

The accuracy of the individual stage measurements is assessed by the unit mean quadratic error, calculated from the difference of measurement back and forth "m0" and the unit mean quadratic error calculated from the levelling circuit closures "M0". The values of these intermediate errors in recent years are given in Table 1.

Table 1 Overview of mid-range errors over the last five stage measurements

Measurement	Date of measurement	Water level	Temperature	Medium error in mm	
47	08.04.2016	351,74 m a.s.l.	20,0 °C	m_o = 0,42	M_o = 0,76
48	28.09.2016	351,52 m a.s.l.	21,0 °C	m_o = 0,35	M_o = 0,61
49	25.04.2017	351,47 m a.s.l.	12,0 °C	m_o = 0,24	M_o = 0,48
50	25.09.2017	351,26 m a.s.l.	16,0 °C	m_o = 0,23	M_o = 0,47
51	18.04.2018	351,33 m a.s.l.	22,0 °C	m_o = 0,17	M_o = 0,43
52	18.09.2018	351,30 m a.s.l.	20,0 °C	m_o = 0,24	M_o = 0,62

Table 2 shows vertical displacements on the reference elevation points on the left and right sides for the last three stage measurements and vertical displacements from the baseline measurement (BM).

Table 2 Vertical shifts of reference points

Reference points			Vertical displacement span from ... to .. mm			
Period			Right site		Left site	
04. 2017	-	09. 2017	-0,1	+0,1	-3,2	+0,1
09. 2017	-	04. 2018	-0,1	+0,1	0,0	+2,1
04. 2018	-	09. 2018	-0,2	+0,5	-3,7	+0,1
BM	-	09. 2018	-16,9	+0,8	-34,1	-1,8

Table 3 Vertical shifts on the objects of Žilina dam

Period			Vertical displacement span from... to.. mm					
			Injection corridor		Inlets to power plant		Outlets from Power plant	
04. 2017	-	09. 2017	+0,2	+1,6	+2,1	+3,5	+1,9	+2,9
09. 2017	-	04. 2018	-1,9	0,0	-3,2	-1,8	-2,2	-1,3
04. 2018	-	09. 2018	+0,7	+3,0	+3,7	+5,0	+2,5	+3,7
BM	-	09. 2018	-55,5	+2,3	-5,2	-2,2	+4,0	+5,0

Table 4 Vertical shifts on the objects of Žilina dam

Period			Vertical displacement span from... to.. mm			
			Weir		Collector	
04. 2017	-	09. 2017	-0,4	+3,4	+2,1	+2,9
09. 2017	-	04. 2018	-2,6	+0,3	-3,3	-1,8
04. 2018	-	09. 2018	-0,4	+4,5	+2,1	+3,0
BM	-	09. 2018	-101,1	+13,1	-91,1	-7,6

All reference altitudes show steady vertical displacements, except for PPVB-5, which is the only one with larger vertical displacement values (p = -3.7 mm in the last measurement). In view of this, the point cannot be considered as a height point. Vertical shifts on selected dam objects are shown in Table 3 and Table 4. Larger values of vertical displacements of the Žilina dam buildings were created during the construction and subsequent filling of the reservoir with water.

Table 5 shows the vertical displacements at the dyke points for the last three stage measurements as well as the baseline measurements. Larger values on the left-side dam are caused by the fact that part of the dam is built on the dam of the Váh and was built during the reservoir filling.

Table 5 Vertical dam shifts

Period			Vertical displacement span from... to.. mm			
			Left dyke points		Right dyke points	
04. 2017	-	09. 2017	-1,4	-0,5	-0,4	+1,8
09. 2017	-	04. 2018	-1,0	-0,2	-1,8	+2,4
04. 2018	-	09. 2018	-1,5	-1,0	-0,7	+1,6
BM	-	09. 2018	-170,5	-30,3	-50,4	-2,6

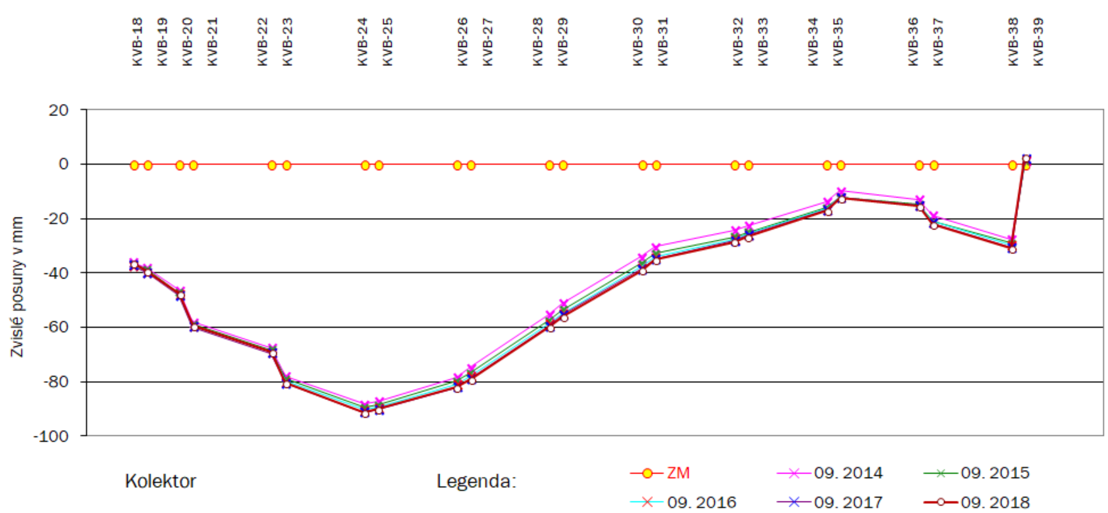

Figure 6 Vertical shifts in the longitudinal section of the Collector objects

For graphical illustration we add in graphical representation the vertical displacements on the selected objects in Figure 6.

Processing of horizontal displacement measurements

The coordinate calculation was performed in the program "Calculation of the Local Position Network Coordinates". The calculation is realized by balancing the measured directions and lengths through the mediating environment. The calculation measured pointers and fixed horizontal length of the physical reduction reduced to a common horizon 350.00 m asl. The calculation was done in two steps. In the first, the coordinates of the reference points, the observational pillars PP-1, PP-2 and the point KVB-7 were calculated. In the second step, the coordinates of the observed points were calculated by the region method. Subsequently, horizontal shifts between each stage measurements were calculated in Microsoft Excel.

The accuracy of direction and length measurements is assessed by the mean square error calculated from the alignment of coordinates in the reference point network and the observational pillars. The maximum mean error values are shown in Table 6.

Table 6 Position measurement accuracy characteristics

Measurement	**Date of measurement**	**Water level**	**Temperature**	**Medium error**	
				my	**mx**
48.	24.04.2017	351,3 m n.m.	10,0 °C	0,9 mm	1,1 mm
49.	25.09.2017	351,3 m n.m.	16,0 °C	2,2 mm	1,1 mm
50.	24.04.2018	351,33 m n.m.	18,0 °C	0,7 mm	0,8 mm
51.	19.09.2018	351,42 m n.m.	16,5 °C	1,1 mm	1,1 mm

The values of horizontal displacements at the reference and observed dam points are shown in Table 7.

Table 7 Horizontal displacements of reference and observed points

Period		Horizontal displacement span from... to.. mm			
		Reference points		Observed points	
04.2017 – 09.2017	dy	-3,4	2,5	-2,3	4,7
	dx	-0,5	1,0	-6,9	2,6
09.2017 – 04.2018	dy	-1,8	4,4	-1,9	2,0
	dx	-3,2	1,0	-2,3	4,1
04.2018 – 09.2018	dy	-6,9	1,8	-3,0	3,0
	dx	-2,1	2,1	-3,4	2,2
ZM - 09. 2018	dy	-9,3	23,3	-30,8	3,2
	dx	-6,5	54,2	-2,3	22,5

For graphical illustration we add in graphical representation the horizontal displacements on the selected objects in Figure 7.

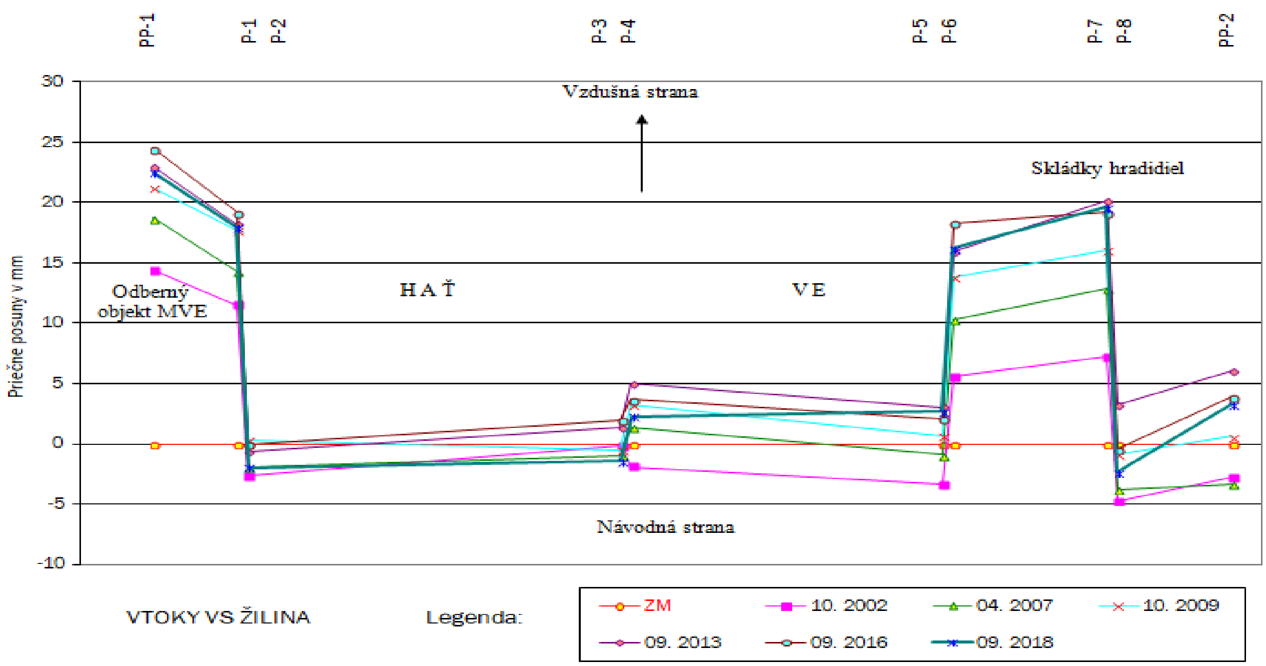

Figure 7 Graphical representation of transverse displacements in longitudinal section on the gates of Žilina dam

Conclusion

The results of the measurement of vertical and horizontal displacements are influenced by the method of measurement, methods of processing the measured data, atmospheric conditions, the shift of the reference points themselves, the quality of the measuring device stabilization, the elastic deformations of the object and others. The accuracy of height measurement by the very precise levelling method of the Leica LS15, Leica DNA 003 and the position using the Leica MS60 is high and has little influence on the measured altitude and positional changes. The use of electronic theodolites, rangefinders and modern computer technology has extended the possibilities of geodetic measurement, processing and measurement methods. These facts were also reflected in the measurements that were made at the Žilina dam.

All reference altitude points show steady vertical displacement values. At present, the changes in vertical and horizontal displacements are no longer large. The total value of the shifts since the beginning of the measurements is higher, but is based on the consolidation of the dam materials after filling the water work. Today, stabilization is now complete and the water work is stable, and shifts do not indicate a problem with the stability of the dam. Therefore, the first 20 years of dam and power plant operation are without serious structural stability problems.

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STEM SHRINKAGE DUE TO WATER STRESS IN DIFFERENT SEASON

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Abstract

The most common symptom of plant water stress is wilt. As the plant undergoes water stress, the water pressure inside the leaves decreases and the plant wilts. Stem radius data obtained from continuously run automatic high-precision dendrometers have been recognized as very valuable for analysis of wood and tree water relations, with practical applications for forest management and the use of irrigation systems. Data for this study were continuously recorded in apple orchard in Horné Lefantovce by dendrometers DD-S. It was used the Zweifel (2016) methodology to compare the zero-growth concept and the concept of line growth. Also were compared dendrometric changes. In May, due to more frequent rain periods the diameter increased from 6.1 mm to 6.7 mm. In September, the increase is minimal, only by 0.1 mm, which is due to the warmer and drier weather. The measurement of dendrometric changes contributes to the accuracy of the determination of the drought period, i.e. water stress plants and determining the time to supply irrigation water.

Keywords: stem shrinkage, dendrometers, drought, water stress

Introduction

Drought is a naturally occurring event that occurs in virtually all of the world's climatic regimes. Drought results in significant economic, social, and environmental impacts in both developing and developed countries. Characteristics of drought impacts differ markedly from country to country and even within a country, depending on the primary economic activities and the vulnerability of the population to extended periods of water shortage. People most closely associate the impacts of drought with the agricultural sector because of its direct effects on plant growth, water availability and food supplies. Certainly, the agricultural sector remains one of the most vulnerable to an extended period of precipitation deficiency in Central Europe and for most other drought-prone regions. Drought is a slow-onset, creeping phenomenon. Thus, in the absence of a comprehensive, integrated early warning system that gathers and assesses the status of the water supplies in the hydrologic system on a regular basis, the severity of droughts often goes undetected until the water shortage reaches crisis stage for many sectors (Wilhite, 2005). When drought occurs, then it can be the cause of lower yields and possible crop failure. The effects of plant water stress vary between the plant species. Early recognition of water stress symptoms can be critical to maintain the growth of a crop. The most common symptom of plant water stress is wilt. As the plant undergoes water stress, the water pressure inside the leaves decreases and the plant wilts. Drying to a condition of wilt reduce the growth of any plant. From an irrigator´s perspective, managing water to minimise stress means knowing plant water availability, recognising symptoms of water stress and planning ahead (Bhattacharjee and Saha in Gaur 2014).

Stem radius data obtained from continuously run automatic high-precision dendrometers have been recognized as very valuable for analysis of wood and tree water relations, with practical applications for forest management and the use of irrigation systems. In order to understand the physiological basis of stem radius dynamics, stem radius changes need to be interpreted in terms of their main components during the growing season, namely irreversible growth of new wood and bark cells, and water-related contraction and expansion of wood and bark (Zweifel et al., 2016). Dendrometers can be used to determine not only the annual thickness growth, but also the distribution of the growth and the rate of expansion and shrinkage of the wood and bark during the year, which reflects the fluctuation of the water stock in the batch. Thus, the growth and physiological response of the trees to seasonal climatic conditions can be identified. Due to the high frequency of data recording, the timing and overall length of the intense thickness growth phase can be determined with great precision by electronic dendrometers. The negative thickness increment then indicates the shrinkage of the trunk, while in the vegetation period it is a consequence of the moisture deficiency, while in winter the trunks naturally shrink due to frost (Sitková and Pavlenda, 2017).

Any water-related processes affecting the stem radius are driven by water potential gradients in the tree, which are mainly induced by transpiration and altered by water availability in the soil, by temperature-dependent hydraulic flow limitations and by osmotic processes in the bark. The transpiration-induced tension in the xylem (i.e. negative water potential) provides the main physical force to transport water within the tree according to the cohesion – tension theory and leads also to dehydration of living tissues. During the day, when transpiration is high, water potentials are low and the stem loses water from elastic tissues, mainly the bark and the cambium, but also from immature xylem (Zweifel et al., 2016).

Material and methods

Data for this study were continuously recorded in apple orchard in Horné Lefantovce (altitude 190 m a.s.l.), Nitra region, Slovakia. The orchard is in the climatic region warm, dry, with mild winter. The average air temperature in January is from -2 to -3 ° C, in July 18 - 19 ° C. The average rainfall in January ranges from 30 to 40 mm, in July it is less than 60 mm and the average annual sum is 550 - 600 mm. The soil moisture regime is slightly moist. The base of the site consists of Haplic Luvisols, local eroded and Calcaric Regosols from loess (Atlas SR, 2019). For study in orchard was used cultivar Jonagored (Malus domestica 'Jonagored'). The variety was bred in Belgium, registered by Jomobel NV. It can be used in warm locations at a site with permeable nutrient adequately moist soil. It freezes in higher altitudes. Irrigation and chemical protection are needed when growing.

Stem radius (SR) was measured by dendrometers DD-S (Ecomatik), which are ideal equipment to fulfil the requests as a mean for exact and continual monitoring of radial and vertical changes in the plant texture, for example stalk, fruit, leaves. It is suitable especially for measurement of young plant parts. The precision of measurement is up to 2 µm, in datalogger using DL18 is ± 0,1 %, output signal is in the range of 0 - 11000 ohm. It is not necessary any connection from external source, equipment calibration. The equipment does not cause plant damage, it is not predisposed to bigger weather changes, and it is possible to use it in external temperatures in the range of -30 to 40 °C and relative air moisture in the range from 0 to 100 %. It is made from rustles steel and aluminium. Temperature coefficient is lower as 0,04 % to one K of the temperature. The equipment weight is only 13 g, due to it does not cause needless load on the plants. Standard length of the cable is 5 m with possibility of prolongation on 100 m (Bárek et al. 2016, Ecomatic, 2007). Data were collected by datalogger in 60 minutes interval.


Figure 1 Dendrometer DD-S and datalogger (Kišš, 2018)

In addition to various numerical approaches that use characteristics of stem radius changes without explicitly distinguishing between the two physiological components, there are two partitioning approaches described in the literature, which are based on different concepts of how growth processes develop during periods of stem shrinkage, that is, increased tree water deficit (TWD). The first concept assumes linear growth between two SR peaks (the LG concept), and the second concept assumes zero growth during periods of stem shrinkage (the ZG concept).

<u>The LG concept</u> (linear growth during periods of stem shrinkage) uses an envelope curve encompassing stem radius peaks to partition stem radius changes into growth-induced irreversible stem expansion (GRO) and tree water deficit-induced stem shrinkage (TWD).

<u>The ZG concept</u> (zero growth during periods of stem shrinkage) assumes that growth stops completely as soon as stems start to shrink. GRO is defined as the difference between the current SR reading (SR_t) and the highest previous SR reading (SR_{max}), when SR_t exceeds SR_{max}. SR_{max} is not restricted to a certain period and may have occurred minutes, days, or even months previously (Zweifel et al., 2016).

Results and discussion

The data for this study were measured from 9.5. to 4.6.2018 and from 1.9. to 1.10.2018. We compared dendrometric changes in growth time in May and after the summer season in September.

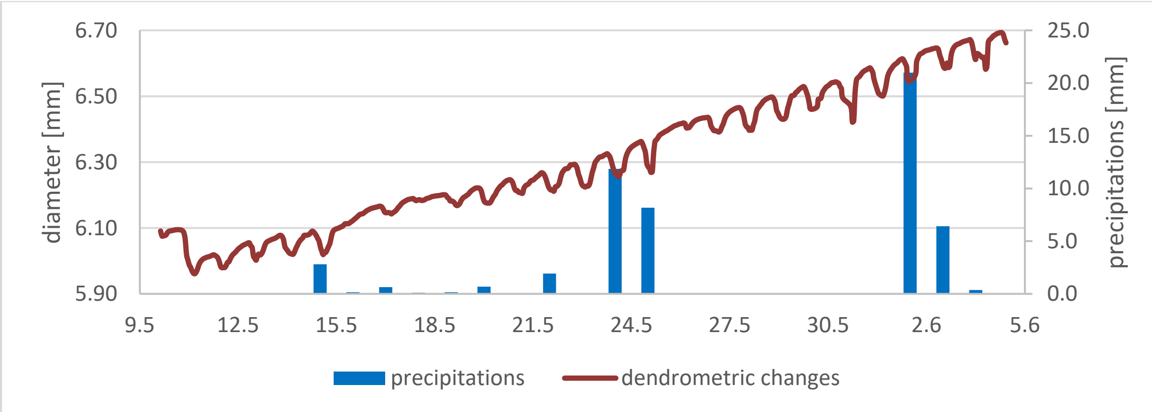

Figure 2 Dendrometric changes in comparison with rainfalls in May

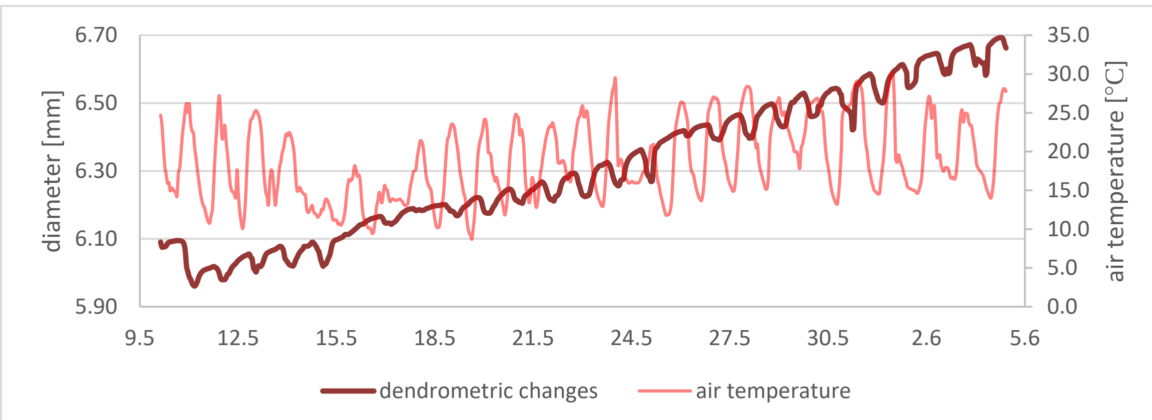

Figure 3 Dendrometric changes in comparison with air temperature in May

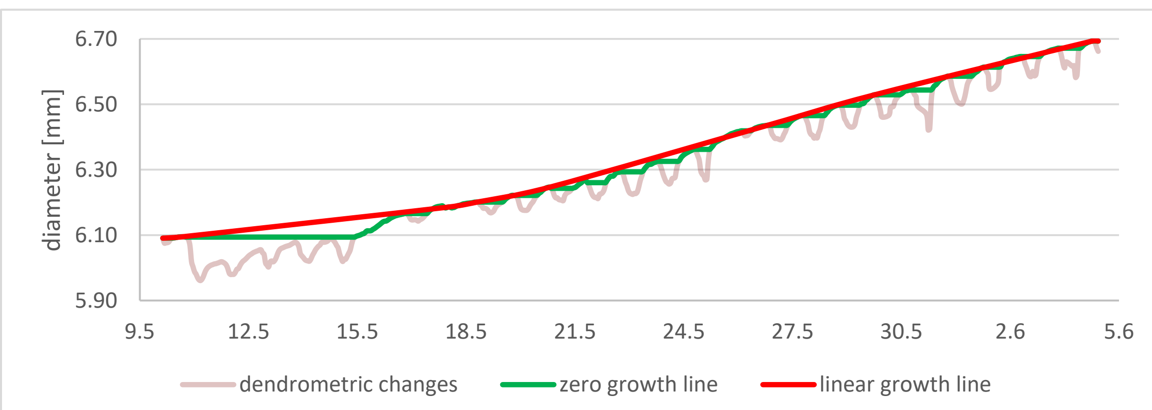

Figure 4 Dendrometric changes in comparison with growth lines in May

Dendrometric changes are influenced by changes in water content in tissues. If we compare the concept of line growth and zero growth, it is seen that during first days of measuring, the average of the branches diminished. Despite the growth, stem radius did not reach the values as at the beginning of the measured period. After the precipitation from 15th to 19 th May 2018, increased water in the tissues, despite the transpiration and the growth of wood has also intensified. Over the next few days, it is seen increasing differences in shrinkage of the branches, but the amount of water supplied was sufficient to keep the growth of plant branches, because rainfalls in May were more frequent.

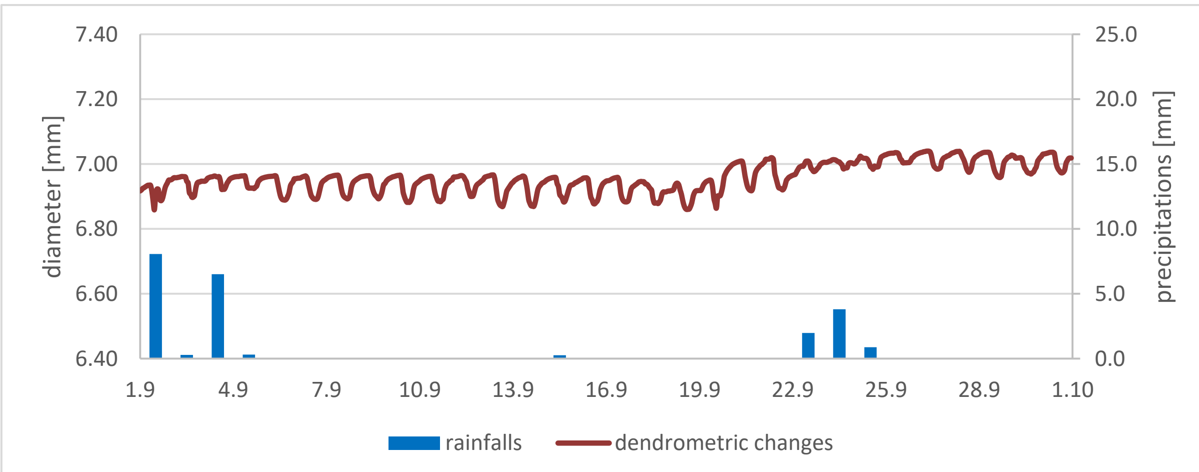

Figure 5 Dendrometric changes in comparison with rainfalls in September

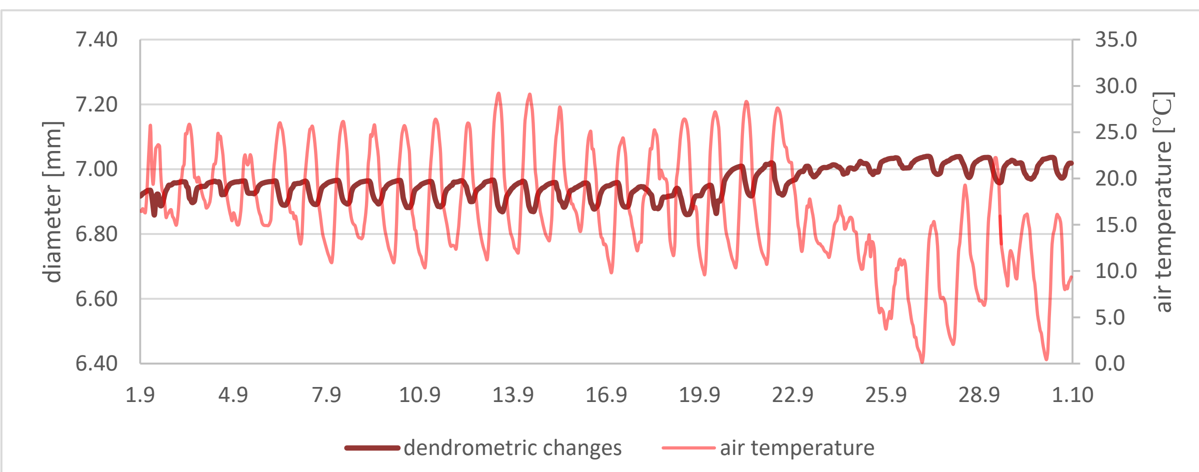

Figure 6 Dendrometric changes in comparison with air temperature in September

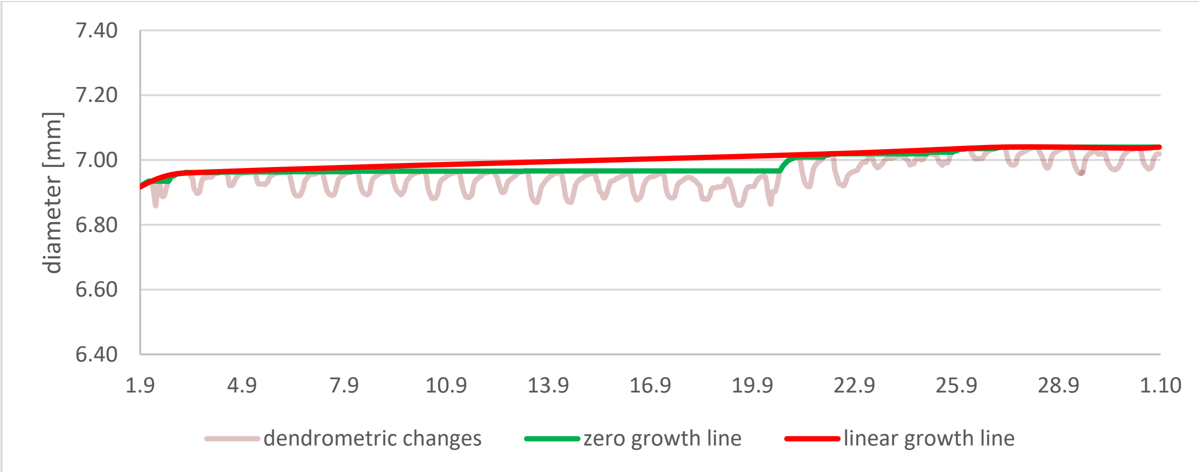

Figure 7 Dendrometric changes in comparison with growth lines in September

In September, the precipitation was less intense than in May, and this was reflected in daily changes in branch averages. From 9th to 20th September 2018, according to the concept of line growth, which copies the highest peaks of growth, it could be said about the lack of water for trees. The concept of zero growth, which according to Zweifel is more accurate, shows us water stress only from 16th to 20th September and the subsequent increase in average after precipitations.

Conclusions

If we use the Zweifel (2016) methodology, for the data measured in the Horné Lefantovce, Nitra region, we can see that the zero-growth concept is more accurate than the line growth concept in our case, which allows real-time responses to water stress in plants. The concept of line growth can only be used after a long series of measurements. When we compare dendrometric changes at different periods, we can see that the increase in wood mass in May was due to more frequent rain periods when the diameter increased from 6.1 mm to 6.7 mm. In September, the increase is minimal, only by 0.1 mm, which is due to the warmer and drier season in which the measurements were made. From the results it can be said that the measurement of dendrometric changes contributes to the accuracy of the determination of the drought period, i.e. water stress plants and determining the time to supply irrigation water.

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COMPARISON OF HYDRAULIC AND MATERIAL LOAD AT THE INPUT OF THE WWTP JELKA AND WWTP VEĽKÉ ÚĽANY

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Abstract

Knowledge of the quality and quantity of waste water supplied to the wastewater treatment plant (WWTP) is one of the basic preconditions for the correct sizing and operation of the WWTP. Waste water can be characterized as a raw material coming to the treatment plant for its processing and therefore its texture (quality) and volume (quantity) need to be known as much as possible. The aim of our work was to compare the hydraulic and material load of two smaller WWTPs in the operation of ZsVS, a.s. (West Slovak Waterworks Company). In the villages of Jelka and Veľké Úľany, a sewage system with waste water being discharged to separate WWTPs in both municipalities has been built. Approximately the same number of inhabitants is drained to both wastewater treatment plants in Jelka and Veľké Úľany, however, the amount of inflowing waste water and the material load of the wastewater treatment plant show significant differences. These differences are probably caused by the inflow of industrial waters from major producers; to a small extent we can also assume the share of ballast, respectively rain water. They reduce the WWTP's operational capacity and increase the economic costs of the operation of public sewerage and WWTPs.

Keywords: WWTP, waste water, material load, industrial waste water, ballast water

Introduction

Man's life causes man to produce pollution that gets to the wastewater. In municipal waste water, especially in small towns and villages where there is no developed industry, household pollution is the dominant share. From the viewpoint of the composition of waste water from households, these are mainly substances that get into the waters of ordinary human activity: preparation of meals, washing, washing and so on. In most cases, they are biodegradable organic substances, but in some cases hardly decomposable substances (fats, oils, paints, etc.) are also introduced into the water.

Wastewater quality is usually defined in mass concentrations (exceptionally in substance concentrations). Commonly are determined in municipal wastewater BOD_5, COD_{cr}, suspended solids (SS_{105}), nitrogen form concentrations (NH_4-N, NO_2-N, NO_3-N, N_{org}), phosphorus concentrations (PO_4-P, P_{tot}) pH, dissolved solids (DS) and the like. In certain specific cases, concentrations of other components, such as e.g. heavy metals, surfactants, fatty acids, sulphates and the like. Fluctuations in the quality of wastewater from households are caused by many factors. It is mainly about the way of life of the population, the type and quality of the sewerage system and so on. Differences in concentrations of some components may be up to several times higher than average values. Indicative values of specific pollutant production by one inhabitant are given in Table 1.

Table 1 The amount of specific pollution and the volume of wastewater produced by one inhabitant (podľa STN 75 6401, 2018)

Substance	***Anorganic*** g/d	***Organic*** g/d	***COD_{Cr}*** g/d	***BOD_5*** g/d	***$N_{tot.}$*** g/d	***$P_{tot.}$*** g/d	***Volume*** l/inhab./d
suspended	15	40	60	30	1	0.2	-
settleable	10	30	40	20	1	0.2	-
unsettleable	5	10	20	10	0	0	-
dissolved	75	50	60	30	10	2.3	-
overall	**90**	**90**	**120**	**60**	**11**	**2.5**	**-**
wastewater	-	-	-	-	-	-	100 - 200

The amount of wastewater from households (also called domestic waste water) is closely related to the living standards of the population. The consumption of water in households depends on the furnishings of the apartments, it is does not only depend on the size of the apartment and the municipality, although there is a tendency for higher water consumption in larger municipalities and towns. The indicative average specific water demand per person is between 100 and 145 liters per day (l/d) in the design of sewage facilities, depending on the type of heating and the type of bath. Real statistical data on actual water production in Slovak households in recent years show a significantly decreasing trend in water consumption, in small municipalities only 60 - 80 liters per inhabitant per day (l/inhab.d)(Derco et al., 2006). Municipal waters also include industrial wastewater, ballast wastewater (foreign) and rain wastewater. The composition of municipal wastewater in Slovakia is rather unfavorable. This is mainly due to the poor quality of sewerage systems, which emit a large amount of ballast wastewater that needs to be subjected to a purification process at the WWTP (Figure 1).

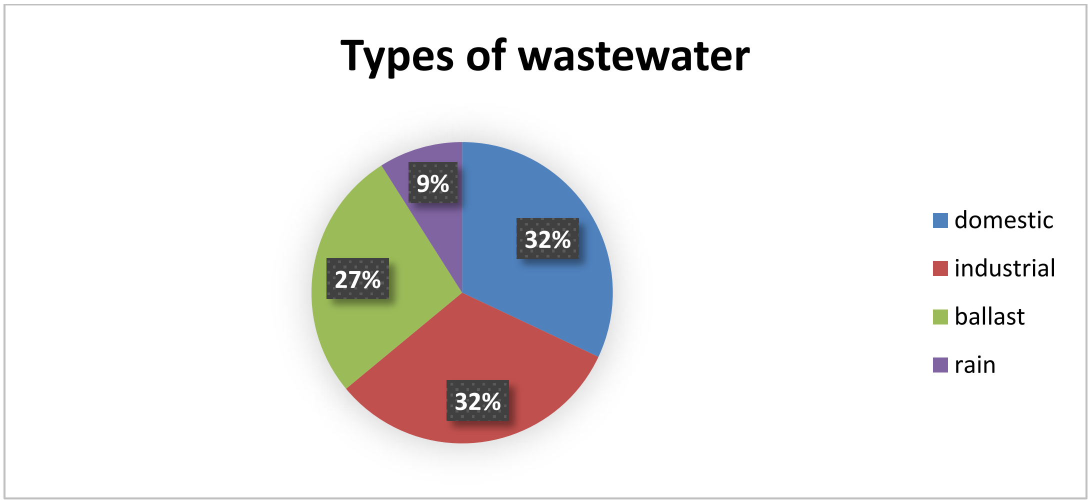

Figure 1 The composition of municipal waste water in Slovakia (Derco et al., 2006)

Material and methods

The village of Jelka (JE) with its 3,800 inhabitants is one of the largest and oldest settlements in the Galanta district. Located between Galanta and Bratislava at an altitude of 123 meters on the northern bank of the Little Danube (Figure 2). The WWTP is located on the left bank of the Little Danube river, which is also the recipient for the discharge of purified waste water. The designed capacity of the Jelka WWTP is 4,500 EI, while there are no industrial wastewater producers on the Jelka public sewerage system. Domestic wastewater from the village of Jelka is discharged by a public sewerage system with a length of 21.24 km with the amount of sewer connections 1,034 pieces. 3,411 inhabitants are connected to the public sewerage system. Domestic wastewater is supplied to the pumping station in the front WWTP. Cesspool wastewater from the faecal sludge acceptance station is also flowing into the pumping station. It is a mechanical-biological WWTP with biological oxidation of carbon and nitrogen, aerobic sludge stabilization and mechanical dewatering of stabilized sludge. The mechanical pre-cleaning line consists of fine machine-wiped screen and a vertical grit chamber. Biological purification is divided into two lines. Each line consists of three nitrification sections and a secondary settlement tank. Sludge management at the Jelka WWTP consists of a storage tank and a sludge dewatering technological line. Purified wastewater is fed from both secondary settlement tanks through a measuring Parshall channel to a WWTP outlet object. The design parameters are shown in Table 2.

Figure 2 Location of the village Jelka (JE) and Veľké Úľany (VU) in Slovakia (map: "© OpenStreetMap contributors")

Table 2 Design parameters of WWTP Jelka

Design parameters		
Inflow		
average dry-weather daily flow Q_{24}	776.25 m^3/d	8.98 l/s
maximal dry-weather daily flow Q_d	1 018.13 m^3/d	11.78 l/s
maximal hourly dry-weather daily flow Q_h	80.14 m^3/h	22.26 l/s
Average daily mass loads		
BOD_5	348 mg/l	270 kg/d
COD_{Cr}	696 mg/l	540 kg/d
SS_{105}	319 mg/l	248 kg/d
$N\text{-}NH_4$	42 mg/l	32.2 kg/d
$N_{tot.}$	64 mg/l	50 kg/d
$P_{tot.}$	14 mg/l	11.3 kg/d

Purified waste water meets the requirements for the quality of waste water discharged into surface waters and complies with Annex 6 to Government Decree 269/2010 Coll. and with a valid final decision (Table 3) for the discharge of purified wastewater from the WWTP Jelka.

Table 3 Water management permission of WWTP Jelka

Water management permission N. 2010/01806				
average dry-weather daily flow *Q_{24}*		average dry-weather daily flow Q24		*m^3/year*
7.81 l/s		675 m3/d		247,050
	concentration		*Mass Balance*	
	p	**m**		
BOD_5	20 mg/l	45 mg/l	13.5 kg/day	4.94 t/year
COD_{Cr}	80 mg/l	170 mg/l	54 kg/day	19.76 t/year
SS_{105}	25 mg/l	50 mg/l	16.88 kg/day	6.18 t/year
$N\text{-}NH_4$	10 mg/l	40 mg/l 40 mg/l (Z1)	6.75 kg/day	2.47 t/year

Veľké Úľany (VU) lies in the south-western Slovakia on the Danube Lowland between the Small Danube and Black Water, 15 km south-east of Senec and 12 km south-west of Galanta between Bratislava and Nitra (Figure 2). The designed capacity of the WWTP Veľké Úľany is 5,200 PE. Domestic wastewater from the village of Veľké Úľany is drained by public sewerage system, which is 21.28 km long with 1,076 pieces sewer connections. 3,442 inhabitants are connected to the public sewerage system. It is a mechanical-biological WWTP with biological carbon and nitrogen oxidation, aerobic sludge stabilization and gravitational thickening of stabilized sludge. Sewage water from Veľké Úľany will be brought to the last pumping station on the sewerage network in the village and then pumped to the WWTP Veľké Úľany for a degree of mechanical pre-treatment. The mechanical pre-cleaning line consists of fine machine-wiped screen and a vertical grit chamber. From there, the pre-treated waste water is connected via piping to the inlet pumping station. Biological purification is divided into two lines. Each line consists of three nitrification sections and a secondary settlement tank. Sludge management at WWTP Veľké Úľany consists of a storage tank. After filling the storage tank with gravity-thickened sludge, the sludge is discharged to another WWTP for stabilization and dewatering. Purified wastewater from the secondary settlement tanks flows into the pumping station purified wastewater.

Purified wastewater is pumped to the recipient via a measuring shaft. The Recipient is the Black Water flow. The design parameters are shown in Table 4.

Table 4 Design parameters of WWTP Veľké Úľany

Design parameters		
Inflow		
average dry-weather daily flow Q_{24}	897 m^3/d	10.38 l/s
maximal dry-weather daily flow Q_d	1,170 m^3/d	13.54 l/s
maximal hourly dry-weather daily flow Q_h	92.6 m^3/h	25.73 l/s
Average daily mass loads		
BOD_5	330 mg/l	296.4 kg/d
COD_{Cr}	660 mg/l	592.8 kg/d
SS_{105}	303 mg/l	271.7 kg/d
$N_{tot.}$	64 mg/l	57.2 kg/d
$P_{tot.}$	14 mg/l	13.0 kg/d

Purified waste water meets the requirements for the quality of waste water discharged into surface waters and complies with Annex 6 to Government Decree 269/2010 Coll. and with a valid final decision (Table 5) for the discharge of purified wastewater from the WWTP Veľké Úľany.

Table 5 Water management permission of WWTP Veľké Úľany

Water management permission N. 2010/01807				
average dry-weather daily flow Q_{24}		average dry-weather daily flow Q24		*m^3/year*
9.18 l/s		793.3 m3/d		290,348
	concentration		*Mass Balance*	
	p	**m**		
BOD_5	20 mg/l	45 mg/l	15.87 kg/day	5.81 t/year
COD_{Cr}	60 mg/l	170 mg/l	47.6kg/day	17.42 t/year
SS_{105}	25 mg/l	50 mg/l	19.83 kg/day	7.26 t/year
$N\text{-}NH_4$	10 mg/l	40 mg/l 40 mg/l (Z1)	7.93 kg/day	2.90 t/year

The public sewerage and WWTPs in question are owned, administered and operated by West Slovak Waterworks Company. In both cases it is a sewerage system with approximately the same technological composition and technical condition and almost identical number of connected inhabitants.
The amount of waste water flowing to the WWTP is measured by a calibrated induction flow meter at the discharge line of the inlet pump station. Immediate and cumulative flow rates from the induction flow meter are recorded on the control system.

Samples of incoming waste water are taken periodically (24 times a year), they are evaluated by means of physic-chemical analyzes and determinations in a specialized accredited laboratory. Qualified sampling is a prerequisite for the correctness and usability of analysis results. As a rule, the effluent at the inflow during the day changes the concentration of pollution and therefore, for the purpose of monitoring the operation, the 24-hour cast samples, obtained by casting 25 equal-volume samples taken at the same time intervals for 24 hours, are mainly collected.

The obtained values of waste water quantities and the results of physic-chemical analyzes of the inflowing water samples at the respective WWTPs were processed and statistically evaluated.

Results and discussion

The respective WWTPs were evaluated in the last 3 years (2016-2018), the quantities of wastewater inflowing in were recorded daily. The obtained balance values of selected pollution indicators and the average daily inflows are shown in Table 7. Table 8 shows the substance load in equivalent inhabitants according to the specific pollutant production of one inhabitant (1). The recorded amounts of wastewater flowing to the WWTPs in question show significant differences. In 2017, the average amount of sewage discharges in Slovakia was 89 l per inhabitant per day (Enviroportal, 2019). The aforementioned national average corresponds to the quantity of inflowing wastewater at the WWTP Jelka, where the average for the monitored period was 91 l per inhabitant per day. An average of 57% of the wastewater was fed to the WWTP Veľké Úľany (VU) more than it was recorded at WWTP Jelka (JE) in the monitored period. The difference is not due to an extreme in one of the years under review, but the difference found is repeated regularly every year. In the event that the difference would represent a high proportion of ballast or rainwater, the waste water dilution would be reflected in a balance sheet of selected pollution indicators. After analyzing the data obtained from the balance assessment of selected indicators of pollution, it can be stated that the difference is caused mainly by the industrial water inflow from major producers, and the share of ballast and rain wastewater can be expected to a small extent. The mentioned share of ballast wastewater and rain wastewater represents approximately the same share of both WWTPs with respect to the age of the sewerage network (10 and more years), the geographical location of both municipalities and the general trend of the population by draining surface and rainwater into the sewerage. Infiltrated water reduces the operating capacity of the WWTP and increases the economic costs of operation public sewerage and WWTP.

Table 7 Daily flow and mass Balance - year 2016-2018

Daily flow and mass Balance - year 2016-2018								
	Q24		***CODCr***		***BOD5***		***SS_{105}***	
	JE	VU	JE	VU	JE	VU	JE	VU
	m^3/d	*m^3/d*	*kg/d*	*kg/d*	*kg/d*	*kg/d*	*kg/d*	*kg/d*
minimum	252	305	83.0	137.0	29.6	71.4	10.6	25.5
maximum	367	580	2,102.5	1,107.7	1,184.1	657.1	204.2	399.0
average	310	491	251.1	367.0	124.9	186.4	53.4	82.5
median	307	495	211.8	348.7	106.2	175.2	45.1	70.6
85-percentile	344	561	314.5	499.0	150.7	242.4	77.9	106.6
	N-NH4		***Ntot***		***Ptot***			
	JE	VU	JE	VU	JE	VU		
	kg/d	*kg/d*	*kg/d*	*kg/d*	*kg/d*	*kg/d*		
minimum	13.0	12.3	19.7	23.3	2.8	2.9		
maximum	86.0	153.7	188.8	190.1	23.6	20.1		
average	29.9	63.6	41.9	85.0	5.6	6.7		
median	27.6	62.5	38.6	85.2	5.3	6.1		
85-percentile	40.0	94.6	51.3	116.3	6.8	8.8		

The amount of EI expressed by the BOD_5 indicator in the wastewater inflow at the Jelka WWTP was 2,093 EI on average, and 3,059 EI at the WWTP Veľké Úľany. A comparable difference was also found in the pollution inflow in the COD_{cr} indicator. The recorded minimum and maximum values for both WWTPs indicate a high fluctuation in the WWTP loads, which are caused by the sudden discharges of high material load probably from major producers. In the case of the Jelka WWTP, the inflow load was expressed by the BOD_5 to 19,735 EI, which is 4.38 times higher than the design capacity of the WWTP. Relatively significant differences can be observed in the evaluation of the substance load results expressed by the specific pollution produced by one inhabitant (EI) of selected pollution indicators. The EI values expressed by the BOD_5 and COD_{cr}

indicators may be misleading as the degradation of organic contamination can occur in the sewerage network itself. Another reason is the style of life in towns and villages, where in the case of municipalities a substantial part of organic pollution from food residues (production and processing) ends in domestic farming (livestock, compost, etc.).

Table 8 The amount of specific pollution and the volume of wastewater produced by one inhabitant - year 2016-2018

The amount of specific pollution and the volume of wastewater produced by one inhabitant - year 2016-2018								
	Q24		***Volume***		***COD_{cr}***		***BOD_5***	
	JE	VU	JE	VU	JE	VU	JE	VU
	m^3/d	*m^3/d*	*l/inh./d*	*l/inh./d*	*EI*	*EI*	*EI*	*EI*
minimum	252	305	74	89	692	1.142	493	1.190
maximum	367	580	108	169	17.521	9.231	19.735	10.952
average	310	491	91	143	2.093	3.059	2.082	3.106
median	307	495	90	144	1.765	2.906	1.770	2.920
85-percentile	344	561	101	163	2.621	4.158	2.511	4.039
	SS_{105}		***N_{tot}***		***P_{tot}***			
	JE	VU	JE	VU	JE	VU		
	EI	*EI*	*EI*	*EI*	*EI*	*EI*		
minimum	193	463	1,791	2,120	1.120	1.148		
maximum	3.713	7.254	17.164	17.281	9.440	8.039		
average	971	1.501	3.809	7.726	2.240	2.673		
median	819	1.284	3.509	7.747	2.100	2.453		
85-percentile	1.416	1.939	4.660	10.576	2.722	3.522		

There is a significant difference in the load expression using the SS_{105} pollution indicator. Average values of 971 EI resp. 1,501 EI compared to other indicators are lower. The 55 g SS_{105} per capita standard was defined for findings on a single sewerage system, which is also affected by groundwater flushes at the time of a rain event. The partially related reason for the low EI in the indicator is also the difference in lifestyle in towns and villages described above.

In the case of the EI load expressed by the N_{tot} pollution indicator, a significant difference was found between the monitored municipalities. The average EI for the WWTP Jelka (3,809 EI) probably corresponds to the actual material load of the WWTP at a given number of connected inhabitants to the sewerage network and the EI value for the WWTP Velké Úľany (7,726 EI) is significantly higher and affected by the aforementioned significant industrial producer. This also corresponds to the recorded difference in the minimum and maximum EI. Given the significant difference in the nitrogen balance, the food industry (processing of fruits, vegetables), breeding of farm animals and the like can be expected. According to the operator, there are several fruit and vegetable processing companies in Veľké Úľany. For example, the average production of wastewater from fruit and vegetable processing in the US is 11.0-23.0 m^3/t of processed raw material, with a produced load in the BOD_5 pollution indicator of 11.8-13.0 kg/t processed raw material and in the TSS pollution indicator 2.2-6.6 kg/t (Greek Ministry for the Environment, 2019). The characteristic concentrations of selected indicators of pollution in the waste water produced from fruit and vegetable processing are shown in Table 9 (Derden et al., 1999).

Table 9 Characteristics of wastewater from some fruit processing a vegetable processing (Derden et al., 1999)

Characteristics of wastewater from some fruit processing a vegetable processing					
Types of operation	SS_{105}	COD_{cr}	BOD_5	N_{tot}	P_{tot}
	(mg/l)	*(mg/l)*	*(mg/l)*	*(mg/l)*	*(mg/l)*
Vegetables. frozen vegetables. preserves. fruitand vegetable juices	700	5,000	3,000	150	30
Potato processing	700	10,000	3,000	150	200
Potato peeling	1,100	6,000	2,500	200	30
Fruit and vegetable juices	16.51	5,100	2,500	27	23
Sour cherries	91	4,000	2,300		
Blackcurrants	241	4,900	2,600	15	13
Carrots	241	8,600	2,700		

[1] Settleable solids after two hours. ml/l

Table 10 shows the production of drainage water and emission data for slaughter of selected farm animals per tonne. Livestock blood has the highest COD_{cr} content of all liquid meat processing waste. Liquid blood has a COD_{cr} content of about 400 g/l and a BOD_5 of about 200 g/l. Content N_{tot} in the blood is approximately 30 g/l (Tritt et al., 1992).

Table 10 Consumption and emission data for slaughter

Consumption and mission data for slaughter						
	Waste water	**SS**	**COD**	**BOD**	**Ntot**	**Ptot**
	(l/t)	*(g/t)*	*(kg/t)*	*(kg/t)*	*(g/t)*	*(g/t)*
CATTLE carcase	1,623-9,000	11.2-15.9	14,702	01.08.2028	172	24.8-260
PIG carcase	1,600-6,000	0.12-5.1	3.22-10	2.14-10	180-2,100	20-233
SHEEP carcase	5,556-8,333			9	1,556	500
POULTRY carcase	5,070-67,400	48-700	15,067	2.43-43	560-4,652	26.2-700

Source: Belgium a (2002), Belgium b (2002), Nordic States (2001), AVEC (2001)

A possible source of significant difference may be the existence of so-called, black connections (unauthorized connection to the sewerage network) but this is unlikely to be based on operator findings. The difference would be a higher amount of illegally connected residents and unregistered residents as they live in Veľké Úľany.

The cesspit was not rated in the evaluation with regard to imported quantities, their processing and the actual sampling of the inflow of pollution in the case of both WWTPs.

Conclusions

When comparing the WWTP Jelka and the WWTP Veľké Úľany, significant differences were found in the hydraulic and material loading of the WWTPs in question with respect to the number of connected inhabitants and the character of the sewerage network in the given municipalities. Based on the results of the work, it is assumed that the source of higher hydraulic and material load at the WWTP Veľké Úľany is a high proportion of industrial wastewater probably from important producers. This statement is also reflected in the high fluctuations in the material load, which were confirmed by both WWTPs. High levels of specific pollution production (EI) of selected pollution indicators (mainly BOD_5, COD_{cr}, N_{tot}) indicate inflow of industrial wastewater from producers oriented on the food industry. For a thorough analysis of the source of the detected significant difference in the hydraulic and material load of the WWTPs, it would be necessary to thoroughly examine and verify the proportion of individual wastewater. In the case of ballast wastewater and rainwater, carry out monitoring of the sewerage network with regard to the detection of seepage water, black connections and the introduction of rain gutters into the sewerage system. In the case of industrial waste water, a thorough examination of business entities with an emphasis on the character of production and character of produced wastewater, their quantity and their disposal. In justified cases, carry out additional sampling of representative samples at a given time and location of the sewerage network to verify the character of the wastewater. Thoroughly qualitative and quantitative knowledge of waste water at the inlet for treatment into WWTP is important for ensuring smooth operation of WWTP, optimization of technological process of wastewater treatment, sludge management of WWTP and ensuring of necessary quality of purified wastewater discharged into recipient in accordance with valid legislation.

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COURSE OF CHANGES IN THE WATER LEVEL BY THE EFFECT OF VARIOUS DENSITY AND HEIGHT OF VEGETATION – SURFACE ROUGHNESS

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Abstract

Flooding is the nation´s most common, costly and deadly natural hazard and it also a natural part of the rivers processes, serving to improve water quality and provide essential habitat to species among other benefits. Flood occur during or after heavy rains, when snow melts too quickly, or when dams break. The identification a critical area where the flood can happen becoming everyday more pressing for our society. A hydraulic model play an important role for determining flood inundation areas. In this paper we were comparing dispersion of flood effected by the various roughness of surface. This roughness was calculated by the height and density of plants: corn, sweet beet, wheat and the uncovered surface. The results were based on the realized research on Easter Slovak Lowland (ESL). Subject to our research was hydro melioration channel of total length 900,56 m. Simulation were carried out by the Nays2DH programme. The largest flood was with uncovered surface followed by corn, sweet beet and wheat. Results showed us, that model very sensitive reacted to change of density and high of vegetation on the surface and evaluated flood dispersion expected.

Keywords: flood, roughness, density, vegetation

Introduction

Water flow is a basic characteristic of water ecosystem. Under this concept, we know movement of water mostly in one way. Hydrodynamics deal with physical regularities which flowing fluid is directing and forces acting on solid bodies located in aquatic environment. By the time perspective we recognize steady flow, when a speed is constant and unsteady flow, when a speed is changing by the time (Zhang, Shen, 2007). Water flow in waterbed is three-dimensional, time and spatially variables (unsteady flow), characterized by density of field, speed vector, temperature and pressure. By the Fisher (1979), transport processes which lead to dispersion of polluting substance in ground flow, we can divide to advection and dispersion. After that, we can divide dispersion on a molecularly and a turbulently. The assessment of flood risk is a difficult task and usually requires solution of a flood routing problem as a part of the assessment. Due to the large number of scenarios that must be developed and analyzed, simplified numerical models are used for the computation of flooded areas in each scenario (Angelo et.al 2002). Flooding in natural channels is a three-dimensional hydrodynamic process that is typically simulated by using models that are simplified for idealized environmental systems based on certain assumptions. The structure of a hydraulic model can be described by its governing equations for river channel and floodplain as well as how these equations are solved in one (1D), two (2D), or three dimensions (3D) (Liu et.al. 2017). The Manning n value is quantitatively evaluated for flow in heavily vegetated channels. An existing hydraulic model is modified to predict stage-discharge curves for channels with nonuniform cross sections, sand and gravel-bed materials, and flexible or nonflexible riparian vegetation. The model is based on a version of the flow momentum and continuity equations that account for lateral shear. The model accounts for the effects of vegetation using empirically calibrated flow resistance equations that incorporate measurable physical properties of vegetation (Darby, 1999). A shear stress, often denoted by τ, is the component of stress coplanar with a material cross section. Shear stress arises from the force vector component parallel to the cross section of the material. Normal stress, on the other hand, arises from the force vector component perpendicular to the material cross section on which it acts. Shear stress arises from shear forces, which are pairs of equal and opposing forces acting on opposite sides of an object.

Material and methods

By the receiver Leica GS 12 we did a collection of GPS data's required for profile creation. The extreme low weight of apparatus provides brilliant ergonomics. The device was developed for most challenging environment with IP 68 protection against dust and for diving to 1m. A receiver supports the reception of all used and planned GNSS signals on 120 channels. By the RTK (Real Time kinematic) measuring form we can collect data. The static accuracy RTK stated by producer at horizontal measuring is 5 mm + 0,5 ppm and at vertical measuring 10 mm + 0,5 ppm. The corrections are receiving by the newest format RTCM 3.1. Simulations were processed in programme iRIC (International River Interface Cooperative). This program was developed in 2007 by Professor Yasuyuki Shimizu and Dr. Jonathan Nelson with the purpose of developing a software for numerical simulation of flow and morpho dynamics in rivers. One of the parts of programme iRIC is Nyays2DH solver. Nays2DH is a computational model for simulating unsteady horizontal two-dimensional flow, sediment transport and morphological change of bed and banks in rivers.

In this study we were comparing an effect on water level and shear stress by different roughness characteristic on hydraulic model. For our simulation we selected the most commonly grown crops at the lowland: corn, sweet beet, wheat and the uncovered surface. In Nays2D, resistance exerted by vegetation is set with the drag coefficient of vegetation C_D and the area of interception by vegetation per unit volume a_s. The area of interception by vegetation per unit volume a_s can be set in each computational cell. The area of interception by vegetation per unit volume a_s is calculated with the following equation proposed by Shimizu et al:

$$a_s = \frac{n_s D_s}{{S_s}^2} \qquad \text{(1, iRIC manual)}$$

where: n_s is number of vegetation,

D_s is the average diameter of trunks and

S_s is the sampling grid width.

The height of the plants, we selected as the average height of the plants in the growing season.

Table 1 Input data of density a_s and height of vegetation to the model

Plant	***a_s***	***Height of plant (cm)***
Corn	*0,14*	*200*
Sweet beet	*0,60*	*50*
Wheat	*0,75*	*100*
Without vegetation	*0*	*0*

Source: Author (2019)

Research and collection of data were realized on ESL. A hydro melioration channels of our interest has a total length 2 094m. The subject of our study was an initial stretch of 900,56 m in length. In the program Nays2DH we made a detailed raster network with using the cross-section profiles. Between values, that entered to model and during all simulations and was constant was water flow, we determined this value Q = 5 $m^3.s^{-1}$, manning coefficient of roughness 0,03 for banks and bottom. For the ground overbanks was roughness identified by the height and density of vegetation.

Shear Stress (τ) is a measure of the force of friction from a fluid acting on a body in the path of that fluid. In the case of open channel flow, it is the force of moving water against the bed of the channel. Shear stress is calculated as:

$$\tau = \varphi D S w \qquad \text{(2, iRIC manual)}$$

where: τ is a Shear Stress (*N/m*^{2})

φ is a weight density of water (*N/m*^{3})

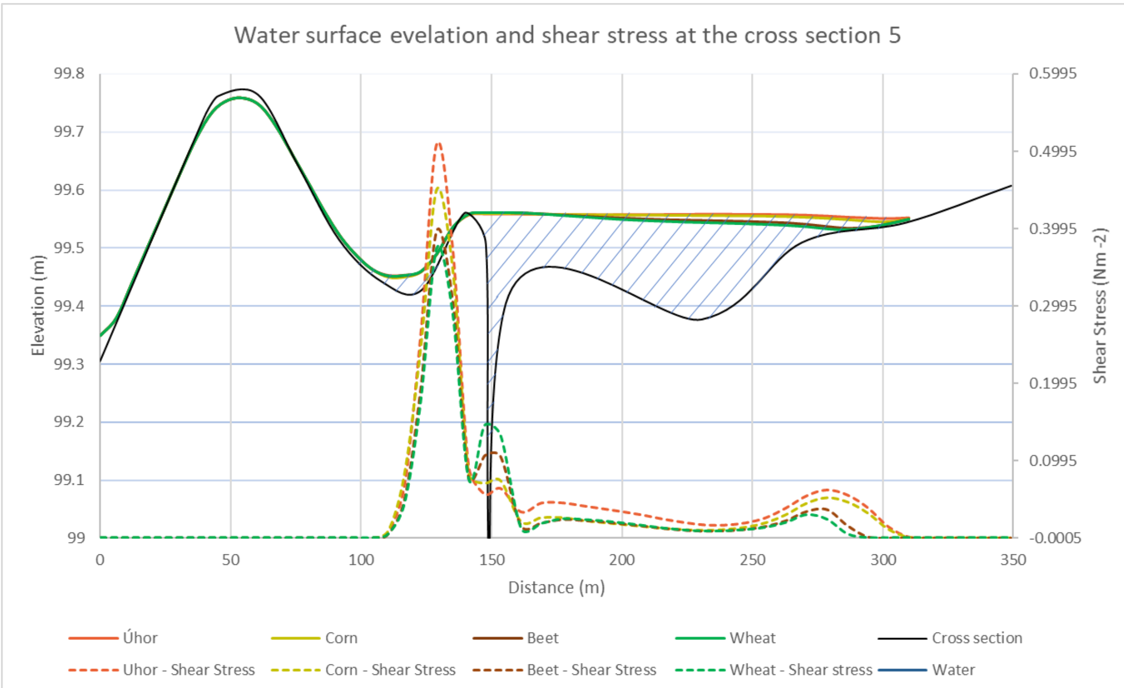
D is average water depth (*m*)

Sw is water surface slope (*m/m*)

Results

Throughout the time of simulation (40min) three pics are shown of distributing a floodplain by different roughness values. We can see that the largest flood was with surface covered without vegetation, where density and height of vegetation was 0, what was expected. Also, with the corn was much bigger than with wheat and sweet corn, where a density of plants is higher than by the corn. A smallest flood was with the wheat, where is the water velocity an effected by the higher density of plants. By the established flow, a flood was localized from the cross section 5, where the water went out of the channel and the flood started.

In the graph we can see elevation of the water in the cross section 5, and the point where does the shear stress is the biggest. Is it located behind the left edge, where a water falling across the edge. Also, the biggest shear stress and water elevation was with 0 roughness, presented like surface covered by nothing, followed by the corn, sweet beet and wheat.



Graph 1 Water surface elevation and shear stress at the cross section 5
Source: Author (2019)

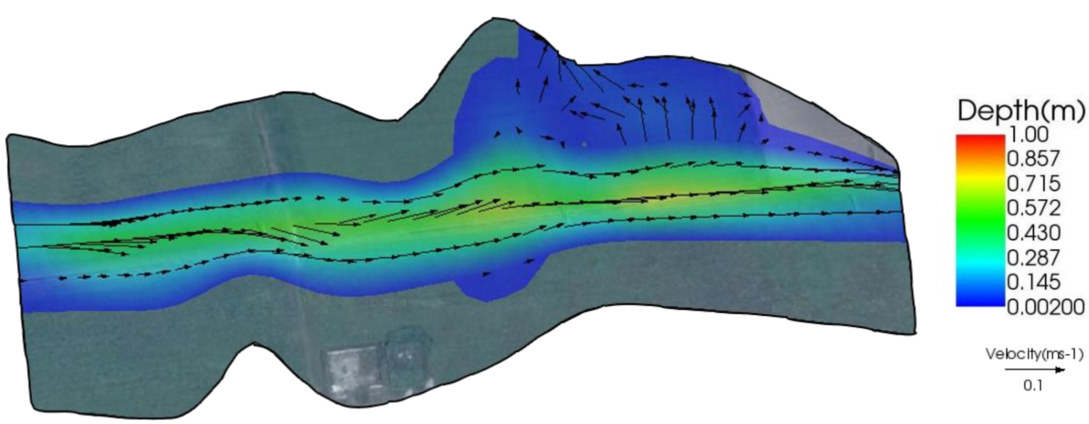


Figure 1 The map showing a flood over the banks of the channel and the way of velocity - Without vegetation

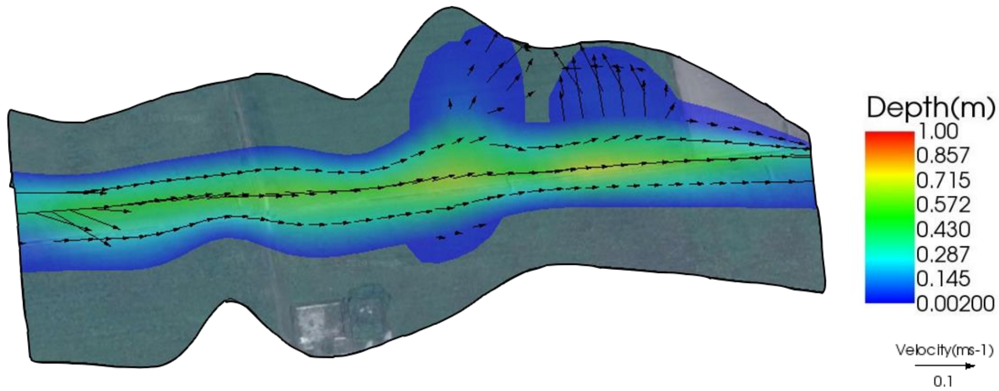


Figure 2 The map showing a flood over the banks of the channel and the way of velocity – Corn

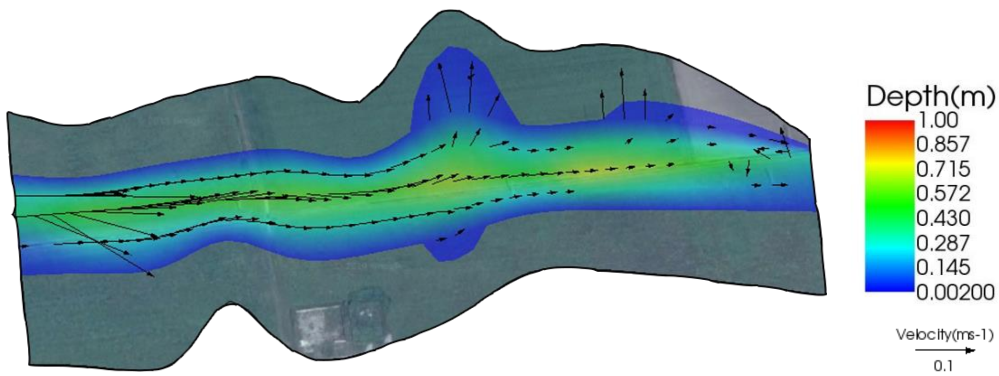


Figure 3 The map showing a flood over the banks of the channel and the way of velocity- Sweet been

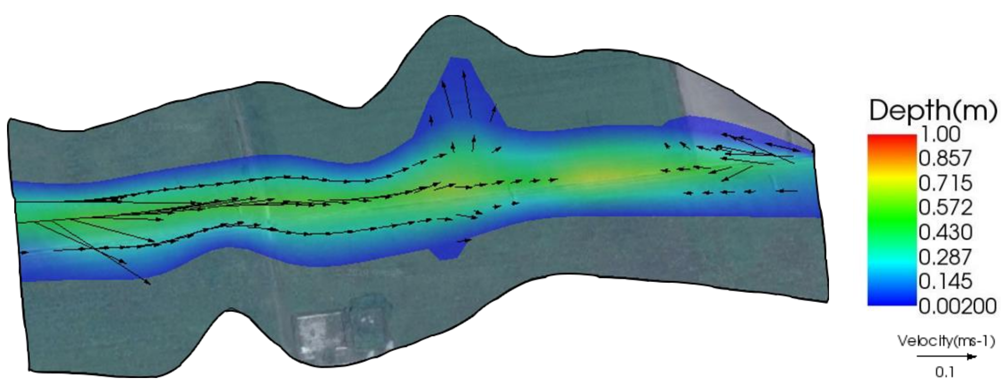


Figure 4 The map showing a flood over the banks of the channel and the way of velocity - Wheat

Conclusions

Computer technology and the associated use of mathematical models provide us with a very effective solution for water problems. By the different models is possibly made a simulation and make an evaluation of dispersion pollution in river without intervention to the environment. The results show us that iRIC programme with model Nays2DH can simulate a flood in the interested area very sensitive reacts on the change of vegetation anywhere in the profile. From the results, we can say that a dispersion of flood is affected by the roughness of the surface. The biggest flood was expected and simulated when the surface wasn't covered by the plants. On the other hand, the lowest flood was when surface was covered by the wheat. Wheat has the bigger density of plants ($1m^2$) than corn or sweet beet.

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DIVERSITY OF ANTIOXIDANTS IN SELECTED HORTICULTURAL CROPS

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Abstract

Recently, there has been growing interest in research into the role of plant-derived antioxidants in food. The beneficial influence of many foodstuffs and beverages including fruits, vegetables, tea, and coffee on human health has been recently recognized to originate from their antioxidant activity. Increasing evidence suggests that a healthy eating strategy with increased consumption of plant-based foods plays important roles in the prevention of chronic diseases, such as heart disease, cancer, stroke, diabetes, Alzheimer's disease, cataracts, and age-related function decline. At the same time, there is an increased demand for horticultural crops that have beneficial health benefits. Among the crops with high content of antioxidant compounds also belong well known *Capsicum annuum L., Cucurbita moschata Duch. and Allium cepa L. Capsicum annuum L.* is an atractive crop with many phytochemicals, vitamin C, carotenoids, tocopherol and flavonoids. . *Cucurbita moschata Duch.* is a significant source of carotenoids and phenolic compounds. Similary, *Allium cepa L.* contains a high level of polyphenols and vitamin C which are good antioxidant agents.

Keywords: antioxidants, oxidative stress, *Capsicum annuum L., Cucurbita moschata Duch., Allium cepa L.*

Introduction

There is a trend nowdays of rapid improvements in medical technology and natural preparations, which is considered as a suitable supplement or even as a main agent in treatments and prevention of various diseases. Many researches focus more and more on production of bioactive components in horticultural crops and their antioxidant properties. Since horticultural crops are a good source of significant components with beneficial effects on human organism, there is a growing interest not only of scientists, but even common people. The main groups of these components are polyphenols (phenolic acids, flavonoids), carotenoids, sulphur compounds, vitamins, minerals etc. At the same time, there is a critical increase of civilization diseases in world such as cancer, cardiovascular diseases, diabetes, obesity. World Health Organization recommand minimal amount of vegetable and fruit intake in 400 – 500 g daily, to prevent civilzation diseases. Horticulural crops as *Capsicum annuum L.* (pepper)*,* *Cucurbita moschata Duch* (pumpkin) *and Allium cepa L.* (onion) offer a wide range of beneficial compounds that can help protect human health. These crops are traditionally grown in our country.

Results

1. **Free radicals**

As a free radical (FR) can be considered any molecular species capable of independent existence that is characterized by unpaired electron in an atomic orbital. Most of free radicals share some common properties, that are consequances of the presence of an unpaired electron (Lobo et al., 2010). According to Poprac et al. (2017), free radicals are molecules or molecular fragments containing one or more unpaired electrons, the presence of which usually makes them highly reactive. In fields of scienece, free radicals are known as a reactive oygen species (ROS) or reactive nitrogen species (RNS). Hegedűsová et al. (2016) report, that FR can be divided into three main classes according to their forming molecule: FR deduced from oxygen (such as superoxid radical, hydroxyl radical, peroxyl radical, alkoxyl radical, hydroperoxyl radical, as well as non-radical species such as hydrogen peroxide, singlet oxygen, hypochlorous acid, and peroxynitrite); FR deduced from nitorgen (such as nitric oxide, dinitrogen pentoxide) and deduced from organic acids. ROS are the best known FR and most studied in biological systems. The high reactivity of FR gives them the ability to abstract electrons from other compounds, which leads to their own recuperation. Based on this process, the attacked molecule gives up its electron and becomes a free radical itself. Thus, the chain reaction is initiated and starts a cascade of reactions leading to damages of living cells (Phaniendra et al., 2015). These components are also products of normal cellular metabolism. In optimal physiological state of the cell, there is a balance between the amount of free radicals and antioxidant capacity. If this balance is disturbed, so-called oxidative stress occurs. Sources of free radicals, which contribute to oxidative stress formation can be of exogenous or endogenous origin. Among the exogenous and environmental sources at the same, belongs ionizing radiation of X-, γ- or cosmic rays and α particles from radon decay, pesticides, environmental chemicals, chemicalsolvents (such as n-hexane, n-octane, toluene, n-butyl benzene and cyclohexane), heavy metals (their ability of redox acting, such as iron, copper, chromium, cobalt). Endogenously induced oxidative stress has usual an intracellular origin. Mainly the free radicals are originated in various singnaling pathways, metabolic or inflammation processes (Ahmadinejad et al., 2017). According to Bhat et al. (2015), overproduction of ROS and RNS in biological systems and a deficiency of antioxidants on the other side leads straight to oxidative stress. This is happening due to metabolic reactions, which demands oxygen and at the expense of it cause a disturbance in the equilibrium status of prooxidant and antioxidant reactions in living creatures. ROS and RNS are known to have both negative and beneficial roles in living systems. The beneficial roles consist in participation in different physiological effects at their low concentrations in many cellular signaling pathways. The damaging effects of FR occur in biological systems. The overproduction of ROS can damage important biomolecules, such as cellular lipids, proteins and DNA, polyunsaturated fatty acids and carbohydrates (Poprac et al., 2017; Gülçin, 2012). Defence mechanisms are essential to maintain the cell integrity, which is provided by antioxidant system (Hegedűsová et al., 2016)

2. Oxidative stress

Pisoschi and Pop (2015) define oxidative stress (OS) as an excessive production of reactive oxygenated species that cannot be counteracted by the action of antioxidants, but also as a perturbation of cell redox balance. It determines structure modifications and function modulation in nucleic acids, lipids and proteins. OS has a prominent impact on the pathogenesis of numerous diseases. It declines the glucose uptake in musle and fat, decreases insulin secreation. Practically, OS is the base of hypertension pathophysiology and atherosclerosis (Furukawa et al., 2017). It has been shown to be involved in the aging process as well. The hydroxyl radical is known to react with all components of the DNA molecule, damaging both the purine and pyrimidine bases and also the deoxyribose backbone. Permanent modification of genetic material resulting from these damage incidents is the first step involved in mutagenesis, carcinogenesis, and ageing (Valko et al., 2007). Furthermore, it has been demonstrated that oxidative modification products can accumulate in various tissues/body organs, leading to morphological and functional changes disrupting normal organ function. In addition, the oxidative modification products, through positive feedback, can stimulate further ROS creation (for example through the increase of NADPH oxidase activity), which enhances the redox disturbance (Pisoschi and Pop, 2015). Free radical-induced damage in OS has been confirmed as a contributor of neurodegenerative conditions (such as Parkinson, Alzheimer, Huntington's disease and amyotrophic lateral sclerosis). It has been assessed that OS is correlated with over 100 diseases, either as source or outcome (Poprac et al., 2017; Pisoschi and Pop, 2015). Gülçin (2012) reports another definition of oxidative stress. According to him, OS represents an imbalance between the production and manifestation of reactive oxygen species and a biological system's ability to readily detoxify the reactive intermediates or to repair the resulting damage. Oxidative stress is basically caused by two main mechanisms. The concentration of antioxidants is reduced due to mutated antioxidant enzymes, toxins, or the reduced intake of natural antioxidants. The number of oxygen, nitrogen or carbon-based reactive species derived from activated phagocytes is increased in the case of chronic inflammation Application of antioxidants signifies a rational curative strategy to prevent oxidative stress. Natural antioxidants contained in edible or medicinal plants often possess strong antioxidant and free radical scavenging abilities as well as anti-inflammatory action, which are also supposed to be the basis of other bioactivities and health benefits (Li et al., 2015).

3. Antioxidants

Antioxidants are a heterogeneous category of molecules, which play an important role in human health such as preventing cancer and cardiovascular diseases, and lowering the incidence of many different diseases. The beneficial influence of many foodstuffs and beverages, including fruits, vegetables, tea, coffee and cacao, on human health has been recently recognized to originate from their antioxidant activity. Antioxidants are compounds or systems that can safely interact with free radicals and terminate the chain reaction before vital molecules are damaged. They can use several mechanisms: (i) scavenging species that initiate peroxidation, (ii) chelating metal ions so that they are unable to generate reactive species or decompose peroxides, (iii) quenching superoxide, preventing formation of peroxides, (iv) breaking the auto-oxidative chain reaction, or (v) reducing localized oxygen concentrations (Oroian and Escriche, 2015; Gülçin, 2012). All aerobic organisms have antioxidant defences, including antioxidant enzymes and antioxidant constituents to remove or repair the damaged molecules. As with the chemical antioxidants, cells are protected against oxidative stress by an interacting network of antioxidant enzymes (Davies, 1995). From a biological point of view, antioxidants are compounds which already at low concentrations can form relatively stable and non-toxic products in free radical reactions, that prevent further radical chain reactions. The primar defense of the organism is a system of enzymes that reduce the concentration of free radicals. This is represented by enzymes: superoxide dismutase (containing copper Cu), glutathione peroxidase (containing selene Se) and catalase. Similar effects have a low molecular weight compunds such as glutathione, ubiquinol and uric acid (Hegedűsová et al., 2016). Antioxidants are often added to foods to prevent the radical chain reactions of oxidation, and they act by inhibiting the initiation and propagation step leading to the termination of the reaction and delay the oxidation process. For determination of antioxidant ability of food components, the terms of antioxidant activity and antioxidant capacity are often used interchangeably, but it should be recognised that they have different meanings. Activity refers to the rate constant of a reaction between a specific antioxidant and a specific oxidant. Capacity is a measure of the amount (as a mole) of a given free radical scavenged by a sample (Gülçin, 2012). According to Sies (2015), there is specificity inherent in the strategies of antioxidant defense . Obviously, a general term describing a global condition cannot be meant to depict specific spatiotemporal chemical relationships in detail and in specific cells or organ conditions. Rather, it entails these, and directed effort is warranted to unravel the exact chemical and physical conditions and their significance in each case.

3.1. Antioxidants in selected horticultural crops

Consumption of fruit and vegetables, as well as grains, has been strongly associated with reduced risk of cardiovascular disease, cancer, diabetes, Alzheimer disease, cataracts, and age-related functional decline. It is known that prevention is a more effective strategy than treatment of chronic diseases. Plant-based foods, such as fruit, vegetables, and whole grains, which contain significant amounts of bioactive compounds, may provide desirable health benefits beyond basic nutrition to reduce the risk of chronic diseases (Liu, 2003). Among the significant sources of antioxidants in plant food belong carotenoids, flavonoids, vitamin C and E, from the mineral elements selene. Most of the total antioxidant intake in the human diet is represented by carotenoids, fenolic acids, sulfides, flavonoids and lignanes. These antioxidants work together and complexly, while the overall antioxidant effect of their combination is greater than effect of individual antioxidants (Hegedűsová et al., 2016). Gülçin (2012) adds that there may be synergistic effects of these various dietary compounds which are difficult to assess at present. Indeed, the diet may be considered as an orchestra where interactions between constituents may bring about effects which are not the necessary properties of the individual constituents. However, more and more convincing evidence suggests that the benefits of phytochemicals in fruit and vegetables may be even greater than is currently understood because oxidative stress induced by free radicals is involved in the etiology of a wide range of chronic diseases. The hypothesis that dietary antioxidants lower the risk of chronic disease has been developed from epidemiologic studies that consistently show that consumption of whole foods, such as fruit and vegetables, is strongly associated with reduced risk of chronic diseases.

It has been proven that, purified phytochemical (or dietary supplements) has not the same health benefit as the phytochemical present in whole food or a mixture of foods. It is because taken alone, the individual antioxidants studied in clinical trials do not appear to have consistent preventive effects. The isolated pure compound either loses its bioactivity or may not behave the same way as the compound in whole foods (Liu, 2003). The 2010 Dietary Guidelines for Americans recommend that most people, should eat at least 9 servings of fruits and vegetables per day, 4 servings of fruits and 5 servings of vegetables. In addition, recent research suggests that the benefits of bioactive compounds in fruits, vegetables, and other plant foods may be even greater than is currently understood because in vitro and animal studies suggest that they have multiple mechanisms of action beyond antioxidant activity. Because bioactive compounds differ widely in composition and ratio from fruits to vegetable to grains and often have mechanisms complementary to one another, it is suggested that, to receive the greatest health benefits, one should consume a wide variety of plant-based foods daily (Liu, 2013). In the last two decades, research has been intensively focused on biologically active substances and their presence in natural resources. We have selected 3 different horticultural crops, which are traditionally grown in our country. We focused on identifying and describing the individual antioxidant substances occupied by these crops (Hegedűsová et al., 2016).

3.1.1. *Capsicum annuum L.* (pepper)

Capsicum annuum L. (pepper) is a plant belonging to the family of *Solanaceae.* This plant was originally grown in the southern region of North America, but also in the North of South America (Zhigila et al., 2014). Andrejiová et al. (2009) reported that pepper was grown not only in America, but also in northern Mexico. In the past, the peper was also medical because it was grown as a medicinal plant. The first mention of this plant (*Capsicum annum L.*) in Europe were recorded at the turn of the 18th and 19th centuries. *Capsicum annum L.* is one of the most attractive vegetables for consumers, which has a yellow, green, red and orange color. It includes many phytochemicals, vitamin C, carotenoids, tocopherol and flavonoids (Kim et al., 2016a). Škrovánková et al. (2017) reported that one of the most important compounds of pepper are natural dyes (carotenoids), vitamin C and vitamin E, antioxidants and capsaicins. Capsaicin alkaloid and dihydrocapsaicin are considered to be very important components of this crop. According to Karatas et al. (2017) it is a vital source of compounds such as vitamins, especially vitamin C and E, provitamin A, phenolic compounds and carotenoids. These compounds offer advantages and have a positive impact on human health, what enrich the antioxidant supply of food products. Pepper has many positive effects on the human body. It works against cancer, cardiovascular disease, diabetes, obesity, aging and has anti-inflammatory effects. Kim et al.

(2016b) report that *Capsicum annuum L.* is almost the richest source of vitamin C (L-ascorbic acid), phenolic compounds and natural carotenoids. All of these bioactive substances are quite important in human nutrition. Pepper is consumed as a healthy and fresh vegetable and is therefore involved in reducing and preventing various civilization diseases. Pepper is a very nutrious vegetable, it contains only 27 kcal/ 100g. Antioxidant components that influence the stability of pigments play an important role in pepper. Capsaicinoids are mainly located in the veins that contain 10 to 60 times more of these substances than the flesh. Capsaicin is characterized by many biological effects which include: cardio protective influence, antilithogenic effect, antiinflammatory, and analgesia, thermogenic influence, and beneficial effects on gastrointestinal system. Therefore, capsaicinoids may have the potential clinical value for pain relief, cancer prevention and weight loss. Topical application of capsaicin is proved to alleviate pain in arthritis, postoperative neuralgia, diabetic neuropathy, psoriasis, etc. Toxicological studies on capsaicin administered by different routes are documented. Capsaicin inhibits acid secretion, stimulates alkali and mucus secretion and particularly gastric mucosal blood flow which helps in prevention and healing of gastric ulcers. Pepper contains a relatively high amount of flavonoids, which belongs to the health beneficial pfenolic compounds (Valšíková et al., 2013; Srinivasan, 2016). Phenolic compounds derived from plant tissues, especially flavonoids, have been shown to possess beneficial properties for human health and disease prevention , including antioxidant, antibacterial and antiviral properties. Protective effects have been observed for the flavonoids kaempferol, naringenin, and apigenin, and for other phenolic compounds against chronic diseases such as cardiovascular disease, type II diabetes, and certain types of cancer (Lemos et al., 2019). Medina et al. (2012) evaluated the antioxidant activity of pepper from different cultivars usingboth the ABTS and the DPPH method. The values obtained for bell pepper (sweet varieties of Capsicum annuum) were 34.44 μM of TEAC/g fw for the ABTS assay and 60.41% of inhibition for the DPPH assay. In both assays, the results varied significantly according to the cultivar of pepper tested,for instance, “Caribe” and “Bell” were the cultivars that showed highest antioxidant activity in both assays. Mendoza et al. (2015) report, that among vegetables, peppers have been extremely popular for the abundance and types of antioxidants they contain. The phytochemical antioxidants that deserve special mention due to their strong capacity to scavenge free radicals are polyphenols, which are found in high quantities in bell peppers, whose levels vary strongly during growth and ripening and deponds on the cultivar. In their research Fascinato/Robusto variety of bell pepper had the highest rate of antioxidant activity of all cultivars – already 79.65 %, while Jeanette/Terrano variety presented the lowest activity, with 64.90 %. These results are higher than those of Deepa et al. (2006) in red bell peppers, which were found to have an antioxidant activity of 20%–71.7%; for this range, the lowest concentration was presented by the variety Parker and the highest by the variety Flamingo. Peppers are known to be an excellent source of vitamin C. Data from many studies have shown that the concentration of this vitamin increases with fruit ripeness. 100 grams of fresh fruit could give the body up to twice its recommended daily dose. Vitamin C content of the pepper is up to two to five times higher than in lemon. The amount of vitamin C in pepper is on average 180 mg per 100 g of fresh fruit, but some varieties contain up to 400 mg of vitamin C per 100 g of fresh fruit (Hegedűsová et al., 2016). Arimboor et al. (2015) report that an important compounds of pepper involved in antioxidant activity are carotenoids. The red color of capsicum are imparted by carotenoids with more than 50 identified structures. Carotenoids content in this study reports varies from 0.1 to 3.2 g/100 g dry weight with marked difference in composition. The unique keto carotenoids capsanthin, capsorubin and cryptocapsin impart brilliant red color to ripen chilly pods, while the yellow orange color is from β-carotene, zeaxanthin, violaxanthin and β-cryptoxanthin. Most of the xanthophylls in red pepper occur as esters with C12, C14 and C18 fatty acids whereas green pepper extracts comprised mostly of free carotenoids. The carotenoids such as capsanthin and capsorubin with κ-ring as end groups were previously reported to be characteristic of capsicum species. Capsanthin contributes 30–70 % of carotenoids in most of the varieties and cultivars. The proportions of capsanthin and capsorubin increase in the advanced stages of ripening. Significant proportions of capsanthin-5,6-epoxide, capsanthin-3,6-epoxide, cucurbitaxanthin A, cucurbitaxanthin B, violaxanthin, antheraxanthin, capsanthone, neoxanthin, lutein etc. have also been reported in red pepper . Pepper also contains a significant amount of S-methylmethionine, which occurs in nature as a n active form of methionine. This compound is known to protect against gastric ulcers. In addition to above mentioned pepper fruit components with preventive and curative effects on human organism. They reduce the risk of many, especially diseases of civilization. (Valšíková et al., 2013; Arimboor et al., 2015)

3.1.2. Cucurbita moschata Duch. (pumpkin)

Cucurbita moschata (known as well as Butternut squash) is an annual plant, which belongs to the *Cucurbitaceae* family and is grown mainly for its fruits. Cucurbita moschata is a crop, which play an crucial role in the agricultural systems of the world. However, cultivation of *Cucurbita moschata* in Slovakia is only at development stage being cultivated in small areas of the southern parts of Slovak territory. Butternut squash is a significant crop in terms of the content of bioactive substances with antioxidant properties – vitamin C, vitamin E, carotenoids, polyphenol compounds – as well as B-complex and potassium, vitamins are appreciated by the consumer both raw and heat treated. It is suitable for storage, consumption in the fresh state or heat treatment thanks to its interesting sensory properties (Andrejiová et al., 2016). *Cucurbita moschata* is also known for its relatively high content of polyphenols, which form a big heterogeneous group of secondary metabolites. The content of these bioactive substances in fresh fruits is variable, they differ from one species to another, and can also be influenced by external factors – climate, nutrition, habitat, storage conditions, etc. (Sarah et al., 2018). From the nutritional point of view, the key substances in these fruits are mainly pectins, fiber, minerals (Zdunić et al., 2016), carotenoids, polyphenol compounds and vitamin C (Grassmann, 2005) are important in antioxidant activity. Gonzales et al. (2001) report that α-carotene and β-carotene, which are precursors of vitamin A have been significantly represented by carotenoids identified in the fruit of pumpkin. From xanthophylls, lutein have been identified. Other carotenoids, such as phytofluene, ζ-carotene, neurosporin, violaxanthin, neoxanthine, flavoxanthine, have been reported to a lesser extent. Other authors also recall the presence of β-cryptoxanthine xanthophyll (Burri et al., 2016). The importance of carotenoids for humans is in the provitaminic activity and the antioxidant effect, ie in the deactivation of reactive forms of oxygen (singlet oxygen, superoxide, peroxyl radical), which in excess cause oxidative stress, negatively affecting the body. The principles of the antioxidant effect have been demonstrated by a series of different experiments both in vitro and in vivo. It is possible that carotenoids have the ability to inhibit the transformation and reproduction of cancer cells and also regulate the expression of genes playing an important role in the formation of certain types of cancer (Merhan, 2017; Bogacz-Radomska - Harasym, 2016). Carvalho et al. (2015) examined 20 different genotypes of *Cucurbita moschata*, while the total carotenoid content in the fresh matter ranged from 12.46 mg/100 g to 69.9 mg/100 g. Priori et al. (2017) compared the variability of 10 genotypes. In terms of total carotenoid content, values ranged from 10.8 mg/100 g to 36.7 mg/100 g of fresh matter. In both of the cases the fruits were grown under the brazilian climate conditions in both cases, which could have had a significant impact on the bioactivite properties of the pumpkin. Santos et al. (2017) analyzed *Cucurbita moschata*, the Menina brasileira variety, and found the average total carotenoid content in value of 24.80 mg/100 g of fresh matter. Hegedűsová et al. (2016) reports the following order of preventative effects of these idividual carotenoids: lycopene < γ-*Carotene* < α-carotene < β-carotene < zeaxantine < lutein. Carotenoids are generally non-toxic, even when used in high doses. Excessive intake of some of the major carotenoids may also cause carotenodermia, a reversible yellowing of the skin. Some studies suggest that increased uptake of synthetic β-carotene may cause lung cancer, the risky group are smokers, ex-smokers and workers with asbetos. Similary, as with carotenoids, the total polyphenols content (TPC) is affected by many influences such as variety, soil content, humidity, solar intesity, temperature, maturity, harvesting methods, processing methods, storaging etc. Kalkan and Yücecan (2013) report an average value of TPC 173.09 mg GAE/100 g of dry matter. Mendelová et al. (2017) investigated *Cucurbita moschata* varieties and determined the TPC in fresh fruits significantly higher than 443.98 mg GAE/100 g of dry matter 565.44 mg GAE/100 g of dry matter. Tamer et al. (2010) reported an average value of 476.63 mg of GAE /100 g of TPC in the fruit of pumpkin pulp. It is recomanded for a human to take daily 1 g of polyphenols (Hegedűsová et al, 2016). In particular, phenolic acids such as chlorogenic acid, protocatechic acid, salicylic acid, p-hydroxybenzoic acid (Zdunić et al., 2016) may be present from polyphenol compounds. The content of vanillinic acid, p-coumaric acid, sinapic acid in the skin of pumpkin fruits, or the presence of luteolin flavone in the pumpkin pulp (Skinner-Hunter, 2013) was found. Syringic acid, caffeic acid also appeared in the raw pumpkin fruits (Dragovic-Uzelac et al., 2005). Cao et al (2010) report that the flesh of the pumpkin also contains flavonoids from the flavonols group (quercetin, kaempferol, isoramnetine), the flavones luteolin and apigene. Besides the flesh, pumpkin seeds are valuable as well. Pumpkin seeds contain flavonoids and tannins (Dhanalakshmi, 2010). Many phytochemicals, particularly carotenoids and flavonoids, are well-known of capability in cellular redox imbalance modulation, as well as the endothelial and metabolic processes regarding the pathogenesis of inflammatory . Several studies have reported the anti-inflammatory effects of various carotenoids and polyphenols; these phytonutrients have been shown to inhibit the production of pro-inflammatory mediators, such as nitric oxide (NO) and interleukins TNFα (Boumar et al., 2017). The highlight components of *Cucurbita moschata* stay polyphenols and carotenoids and they ability to engage in antioxidant processes, scavengering the free radicals in human organism (Hegedűsová et al, 2016).

3.1.3. *Allium cepa L.* (onion)

Onion vegetables has for centuries maintained a prominent place in cultivation among all cultural plants not only for healing purposes. The most well-known and well-researched species is *Allium cepa L.* This crop belongs to the *Allium* genus and is characterized by health-promoting components with significant effects on human health in the positive way. In addition to its popularity in the healing area, it is attractive in almost every kitchen (Choi et al. 2011). Already in ancient ages its varied range of healing effects was known. One of the first mention of its unique effects comes from China from 2700 BC. In ancient Egypt, these effects have been used to alleviate illness and numerous kind of health problems (Briggsová, 2009). *Allium cepa L.* combine the content of several health-promoting substances. It is rich in minerals, vitamins, polyphenol compounds, most of which are flavonoids (Issa et al., 2013). Bhattacharjee et al. (2013) indicate that *Allium cepa L*. contain 5.7 to 6.5 mg./100 g of vitamin C. The importance of vitamin C lies in its redox metabolic processes, where it shares electrons in enzymatic reactions. It is an antioxidant with a great influence on the disposal of harmful free radicals. It has an important function in the regulation of fat, the metabolism of bile acids and some minerals. Last but not least, it has a remarkable effect on stimulation of antibody production and overall immune system (Ely, 2007). Onion is a significant crop in a terms of TPC content as well. Many factors influence the content of polyphenols in fruits, such as growing conditions, storage and processing of food. In general, the concentration of phenolic acid decreases by maturation, while the concentration of anthocyanin increases (Li et al., 2014). The total polyphenols content depends on the type of source and is strictly affected by its variety. Kavalcová et al. (2016) show the results of the research according to the six onion varieties (Boston, Sherpa, Bingo, Red matte, Diamond, White dry); the highest maturity of polyphenols was in the Red matte variety, which is a red type of onion. These results correspond to many other studies. Ali and Nooshin (2014) report polyphenols content in 100 g of onion ina range of 520.0 mg. Oancea and Draghici (2013) add that in red onion varieties, the proportion of polyphenol substances is higher compared to other varieties. Heleno et al. (2015) notes that onion is a good source of phenolic acids. He indicates 200 mg intake of phenolix acid per day in humans. The most common phenolic acids in the diet are caffeic acid and ferulic acid. According to Cheng et al. (2013), there are 265 - 445 mg of gallic acid and 87 - 259 mg of ferulic acid in 100 g of dry matter *Allium cepa L.*. Research by Liguori et al. (2017) reports the highest proportion of gallic acid, ferulic acid and chloregenic acid. According to Bystrická et al. (2018), sulfur is a key element for the growth and development of onion vegetables. Sulfur compounds act as electron donors and are able to react with free radicals and stop oxidation processes in food products. Addition of sulfur, when growing onions, leads to higher levels of total polyphenols and thus to higher antioxidant activity. Karadenuz et al. (2005) reported that 170 mg of flavonoids are contained in 1 kg of onions. Many studies have confirmed that this varied group of phenolic compounds has exceptionally positive effects on the human body. They slow down aging, favor concentration and memory, help treat neurodegenerative and cardiovascular diseases, have anti-allergic effects and have anti-mutagenic and antiviral effects. Abouzid and Elsherbeiny (2008) report that the content of quercetin (flavonoid) in onions can reach up to ten times the quercetin content of another vegetable. According to Hollman and Arts (2000), 300 mg of quercetin are found in 1 kg of *Allium cepa L.*, while 100 mg in broccoli, 50 mg in apples and 40 mg in blueberries. Lachman et al. (2003) mainly highlights the consumption of red onion varieties. Based on his research, up to 163 mg of quercetin is found in 1 kg of red onion, which is more than three times the content in yellow varieties. Quercetin is considered one of the strongest natural substances used in the fight against cancer. It has been confirmed that it significantly inhibits the growth of gastric, lung, breast, ovarian, colon and many other types of cancer (Hegedűsová et al., 2016) An important compound of routine is also found in onion. Lachman et al. (2003) report that the same amount of rutin as quercetin - 163 mg in 1 kg is contained in the red varieties of *Allium cepa L.* This horticultural crop is one of the most important sources of natural antioxidants, mainly thanks to polyphenol compounds. Lenková et al. (2016) report the following order of antioxidant acitivity: red variety of *Allium cepa L.* (40,58 %) < yellow variety of *Allium cepa L*. (21,09 %) < white variety of *Allium cepa L.* (12,29%). According to Kaur et al. (2009) red onion varieties achieve total antioxidant activity in the range of 63 to 85% and white onion varieties from 14 to 22%.

Conclusion

Nowadays, there is a growing interest in substances exhibiting antioxidant properties, which are supplied to human organisms as food components. It is a fact, that a number of people suffering from civilization diseases is gradually growing. Consequently, antioxidants have become an essential part of food preservation technology and contemporary health care. It is well known that plants which possess antioxidant and pharmacological properties are related to the presence of phenolic compounds (especially phenolic acids and flavonoids) and carotenoids. Growers are increasingly encouraged to grow horticultural crops with increased content of chemoprotective substances. As we state, many researches are devoted to the analysis of such a health promoting substances in different crops. Among the crops with high content of antioxidant compounds also belong well known *Capsicum annuum L., Cucurbita moschata Duch. and Allium cepa L..* These vegetables are popular for ability of their components to act against the free radicals and prevent oxidative damages of important biomolecules.

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PAVEMENT STRUCTURE OF THE TOURIST TRAILS: A STUDY FROM THE KRKONOŠE MOUNTAINS NATIONAL PARK

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Abstract

Recreational use of forests rises, and so rises the usage of the forest transportation network. In many cases, the use of the forest roads as tourist trails is not desirable or possible, be it because of unattractive surroundings of the roads or the absence of the road network in the particularly interesting area. For such conditions, tourist trails are a viable option, with a lesser impact on the surroundings than forest roads, yet providing the traveling comfort and protection of the soil and nature around against the touristic erosion. This paper investigates the best management practices and technical solutions for the surface of the trails in the Krkonoše Mountains National Park. By analyzing the project documentation of the tourist trails reconstructed in the last ten years, the summary of used technical and dimensional solutions was devised. These methods and designs can be transferred and used in other areas as well. Because of the nature conservation in the National park, the use of machinery is extremely limited, the use of local materials is maximized and the design as a whole minimizes its footprint to a level which even small forest owner can manage and build.

Keywords: Tourist trails, touristic erosion, hiking trails

Introduction

For most of the forests, the primary function is wood production. However non-production functions are gaining attention, including the recreational function. To allow this function to work in the full extent, it is necessary to establish accessibility for tourists. In the past, this was mainly achieved by using forest road networks and giving them a secondary purpose.

That is not fully possible, as the forest roads do not always connect the points attracting the tourists as stated by Kvasnička (2008).

In the tourist attractive locations, where no roads were built, the trampled footpaths were created by tourists in the forests. It is, however, desirable to manage the pathways so they pose no threat to the ecosystems. The negative influences can be mitigated not only by trail placement in terrain but also by trail surface design, which should correspond with the location and expected traffic of the tourists.

For most of the European forests, the forest road is being used as the trail. In the Czech Republic the Czech norm ČSN 73 6100-1 (2008) states, the forest road is purposefully built forest communication which is part of the forest transport network and serves mostly for the forest transport and could serve to other purposes, such as cyclist trail or pedestrian tourist trail. This declaration creates the basis on which the technical design of the road is established. Abroad, we can find many forests, which are mainly accessible only by footpaths for tourists. The design of the footpath is commonly minimal and without proper countermeasures against erosion.

ČSN 73 6100-1 (2008) norm also defines the communications for pedestrians as the communications designed solely for pedestrians. It is then classified into pawed walkways, pedestrian trails, and pathways.

The difference between trail and pathway is defined as that the trails have the surface designed for the pedestrian use, while the pathway is without any design features, or only on few small segments.

Also as stated in Forest transportation network norm ČSN 73 6108 (2016), the pathway is limited to the maximum width of 2 meters.

In the above cases, the trail pathways are not considered to be roads. Therefore there is forbidden to use a bike, ride a horse or use sled or ski (§ 20 odst. 1 písm. J Zákon č. 289/1995 Sb., 1995).

If we plan to use the trial for both, pedestrians and bikers, the design should follow norm ČSN 73 6110 (2006) where the joint trails should be wide at least 3.00 m. For small traffic ≤ 50 bikers/h and 100 pedestrians/h, the width can be reduced to 2.00 m, in tight locations to 1.75 m and in special cases and low traffic ≤ 20 bikers/h and 50 pedestrians/h to even 1.00 m. For the pedestrian-only trails, the width should be at least 1.50 m, but the standard is 3.00 m. These criteria can be summarized as table 1 shows.

Table 1 Definitions and design criteria

	Crown width			
	1 m	**2 m**	**3 m**	**4 m**
Forest road			1L type forest road	
			2L type forest road	
			Trail	
Gravel forest road			2L type forest road	
			Trail	
Local modifications	Pathway (trail)		2L type forest road	
			Trail	
Bare road surface	Pathway (trail)		2L type forest road	

As observed by several authors, the forest transportation network is a major source of sediment particles in watersheds with mainly forest land. (Cafferata, 2002; Coe, 2006).
Swift (1988) concluded that the biggest surface erosion is on the soil or gravel roads with the material of the grain size under 5 mm. He also concludes that the exceptional mitigation technique is using grass cover which can reduce the erosion of up to 50 %.
There is, however, the problem with the higher traffic and it is highly dependent on the grass species used, as the resistance to the trampling highly differs among grass species. Cao (2006) proved that some of the grass species are unable to survive 100 travels per year. For most of the species, the limit was 300 travels per year. As stated by Vítková (2012), in case of new trail thread creation, the species composition changes at first – in favor of more trampling resistant species and after another rise in pedestrian traffic, even these species reside and the soil is bare.

Material and methods

For this study, we chose the Krkonoše national park. This was for several reasons. Extreme weather in the Krkonoše mountains accelerates erosion, therefore the advantages and disadvantages of the designs can be seen faster. The requirements on the natural conservation exclude large mechanization and large footprint of the building. This allows the used designs to be easily transferred not only to other protected areas but also allows smaller owners to take advantage of the minimal mechanization requirements.

We investigated the documentation of the reconstruction projects which were realized in the last ten years by the managing organization – Správa Krkonošského národního parku. From the projects, the layer composition was recorded, together with other dimensions like the width of the crown of the trail (walkable surface of the trail without side slopes), cross-slope of the crown (angle of the surface perpendicular to the axis of the trail). In total, 17 projects were investigated. The approximate locations of the trails can be seen on the figure 1.
Figure 1: Approximate locations of the trails

The projects were classified according to the main technical solution of the trail – bare soil/ gravel trails, trails pawed with cobblestones, trails with stone base and the elevated wooden trails. For each class, the analysis of the dimensions was done.

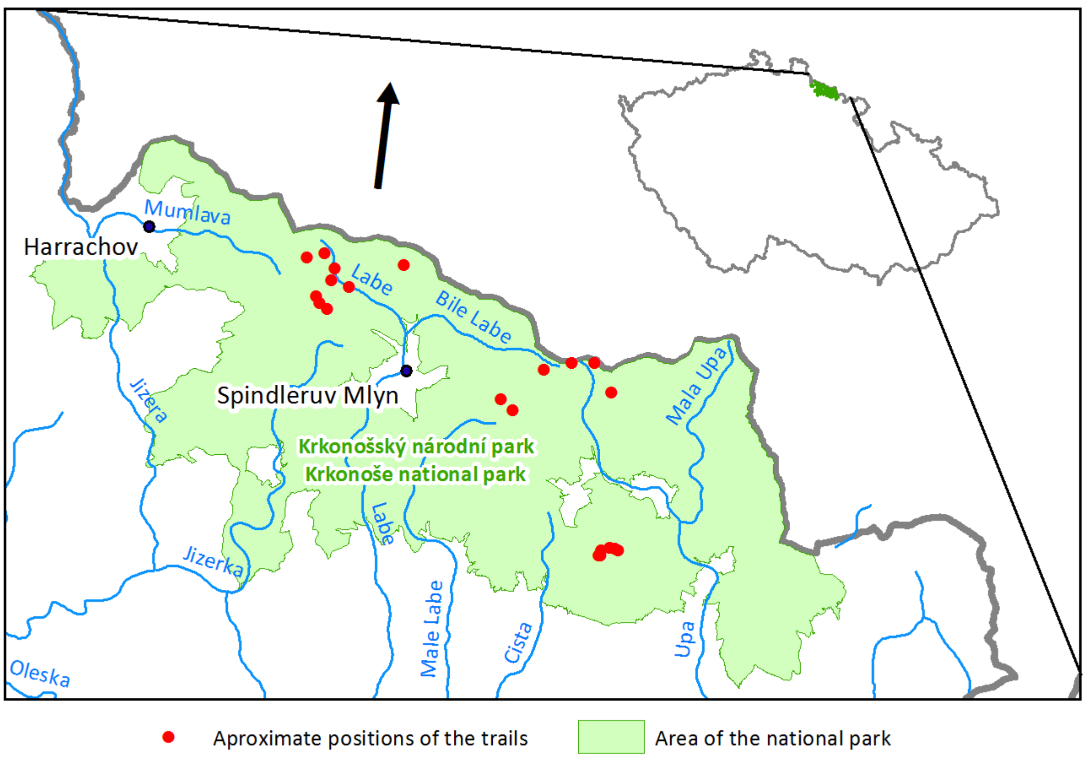

Figure 2 Approximate locations of the trails

For the suggested management practices, the maximal and minimal thickness of the layers is presented, together with the cross slopes used for drainage fo the crown.

Results and discussion

1.1 Soil/Gravel trails

This is the simplest design of the trail. It is created by evening the surface, or with adding gravel material and filler. As for gravel, the standard method consists of layering 20-30 cm of stone with a size fraction of 8-15cm to fill up any depressions. It is overlayered with 10-15cm of gravel in a fraction of 2-8 cm. This is then filled up with a mixture of fine gravel, quarry residues and it is vibrated three times to create a compact surface.
Alternatively, only 25 cm thick layer of 0-63 mm grain size fraction of the gravel can be layered and then covered with fine gravel in the amount of 70 kg/m², which is vibrated or pressed in. The cross water drainage is usually solved by using the Bavarian method, where the slope of the surface is 0% in the middle and goes down up to 8% on the sides. This is a sufficient solution, given the curbs are properly serviced. Alternatively, the simple cross slope of 3% can be used. The open top culverts can be used to catch water and divert it into curbs and away, but it is important to manage the water dispersion, as the gravel taken by it can change the vegetation and conditions on the site (Grab, Kalibbala 2008).
Two of the used designs can be seen in figure 2

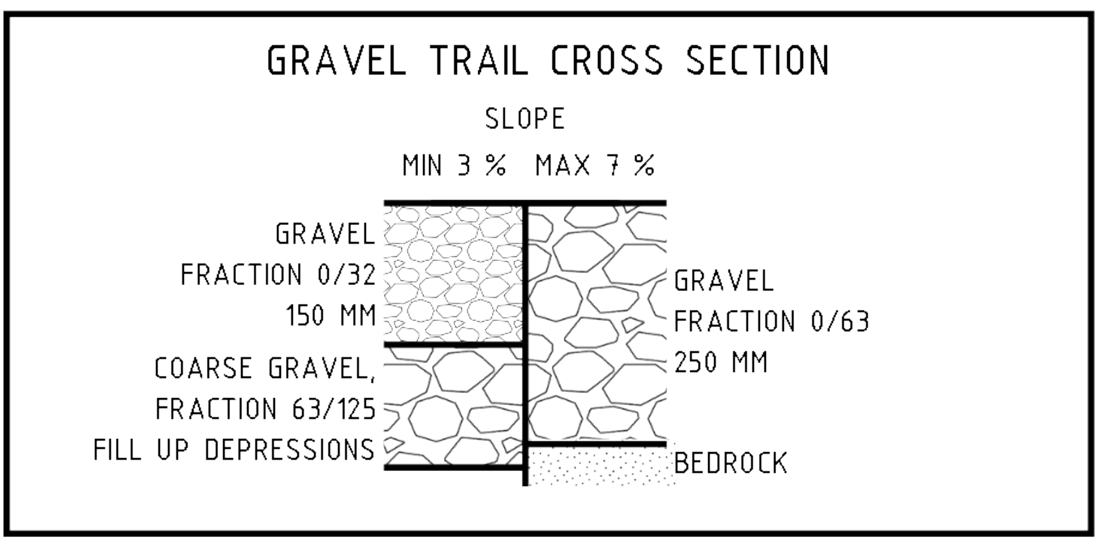

Figure 2 design cross-sections of the gravel trails (source: author)

The soil and gravel roads should be used only in terrains with minimal slope, as trail surface will erode due to the water moving quickly on larger slopes. When the drainage is not solved at all on plane terrains, it leads to trail degradation as can be seen in figure 3

Figure 3 improper drainage of the soil/gravel trail (source: author)

1.2 Cobblestone trails

This trail should be made in the vicinity of the stone source. For example by the stream or river which could provide stones for the pawing. The technology and dimensions depend highly on the stone dimensions. Even though this method is highly resistant to the erosion, it is difficult to be built, as the stones must create a plain for an easy walk. Different dimension of the stones can also cause large gaps, and these must be filled with fine material, which could be taken away by water, then, the stones can start moving and the trail becomes dangerous. Also, if the stones are smoothed from the water erosion in the stream, when wet, they are extremely slippery, so proper culverts and curbs have to be built to minimize the amount of the water on the trail. Cross sections of the used designs are shown in figure 4.

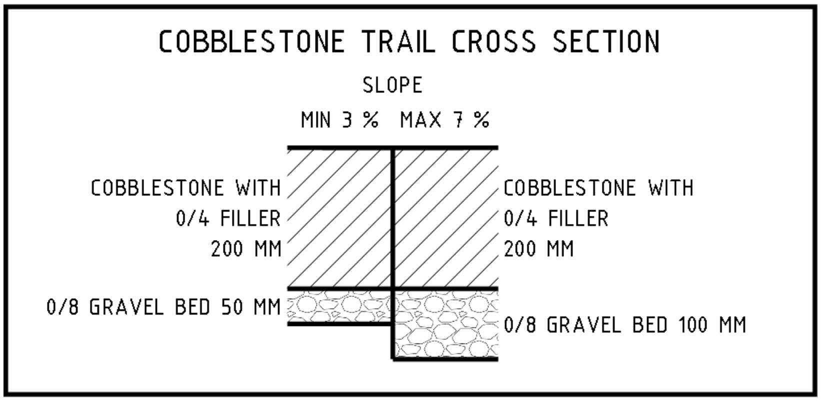

Figure 4 design cross-sections of the cobblestone trails (source: author)

1.3 Stone base trails

This technique is in a way unique for the Krkonoše mountains, but it could be transferred to other locations as well. This method uses large squared stone blocks for the creation of the "fields" which are then filled with wedging smaller and smaller stone shards between the previously layered stones. Then, this base is covered with fine gravel to even the surface. This method was used for the trails used for wood skidding on the sleds and is highly resistant to the erosion when the top fine material is checked and filled up periodically. Without this material, the sharp edges of the shards are difficult to walk on. However, the whole structure is quite capable of diverting the water of the surface without any significant damage to the trail. Cross sections of the used design are shown in figure 5, the detailed layout of the trail is shown in figure 6.

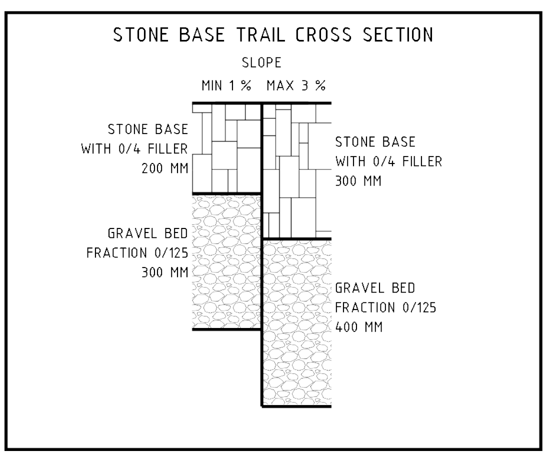

Figure 5 design cross sections of the stone base trails (source: author)

Figure 6 layout of the stone base trail – border field filled with vertically wedged stones (source: author)

Also, the wedging must be done perpendicular to the trailing axis, so the longer edge of the wedge works as a stop for the material transported by any water or wind. The eroded trail with wrongly oriented wedges can be seen in figure 7. The problem of this design is a weight of the border stones, which can weigh several hundred kilograms, and without mechanization, they are quite hard to manipulate.

Figure 7 damaged trail with wrongly oriented wedges (source: author)

1.4 Elevated wooden trails

Used in marshlands and water affected locations, this design can be also used in fragile environments. Because of the contact with ground and moisture from the weather, the oak or larch timber should be used for its longevity. Usual timber profile is 15x20 cm and 15x25 cm which are used on all parts of the trail – the deck, girders, headers, sideguards, piers and spread footers. If necessary, the footers can be elevated on the rockpiles above the terrain. The usual layout is shown in figure 8 and 9.

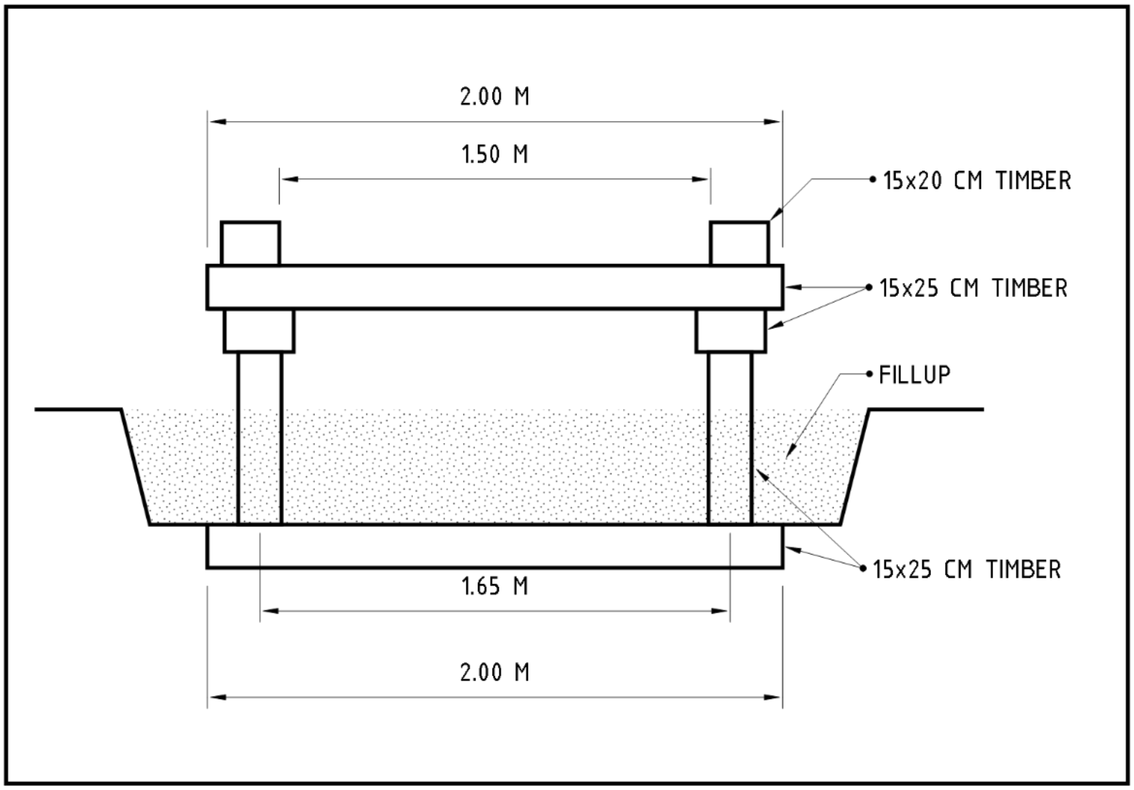

Figure 8 cross section of wooden trail (source: author)

For this type of trail especially, the width should not be less than 1.5 meters, as the pedestrians can comfortably pass each other. Should the trail be used by bikers, people on wheelchairs or parents with kids in prams, the designer should add wooden tracks in usual wheel spawn, for a smooth ride. In less exposed locations, a smaller timber can be used, or wood composite materials. This can be a viable solution as the prices of the oak and larch timber rise due to the bark beetle situation and oversaturation of the market with spruce and pine wood.

1.5 Trail width

Trail width is not consistent across projects and as can be seen in Table 2 it is not In accord with the building codes. This is for several reasons, one being natural conservation requirements - specifically the requirement of not overstepping the footprint of the current trail, not even temporarily for the construction.

Figure 9 alternative design with the rockpile supports (source: author)

Table 2 Trails widths and their relation to the building codes

Trail designation	Trail width in project (mm)	By ČSN 73 6110 (2006)	By ČSN 73 6108 (2016)
Petrovka - Ptačí kámen - Bráddlerova bouda	1500		
Bouda bílé labe - luční bouda 1	1600		
Bouda bílé labe - luční bouda 2	3000		Too wide
Špindlerova bouda - Důl Bílého Labe	3000		Too wide
Labská bouda – Pudlava1	2500		Too wide
Luční bouda- obří bouda	1800		
Černohorská rašelina 1	1000	Too narrow	
Černohorská rašelina 2	1850		
Černohorská rašelina 3	910	Too narrow	
Černohorská rašelina 4	1100	Too narrow	
Černohorská rašelina 5	1000	Too narrow	
Dlouhý Důl - Výrovka	1200	Too narrow	
Horní mísečky - Jestřábí boudy	1200	Too narrow	
Labská bouda - Pudlava 2	2000		
Labská bouda - Pudlava 3	1200	Too narrow	
Růžová hora - Sněžka	2300		Too wide
U čtyř pánů - Česká budka	2800		Too wide
Horní mísečky - Jestřábí boudy 1	1200	Too narrow	
Horní mísečky - Jestřábí boudy 2	1200	Too narrow	

1.6 Trail length

Length of the trails was not studied, as the main focus of this study was on the construction layers of the pavement, and reconstruction was not tied to the whole length of the trails – in several cases, reconstruction was done in sequence, or only specific trail part was considered for the reconstruction, as it was damaged the most.

1.7 Trail price

The data on the price for realization was not available for all projects. Even so, the price could be considered for the reconstructions only.
The price is affected by many factors. Same construction technology was realized in several

locations with different pricing. This can be seen for example on the stone based trails where the price per meter differs significantly, even though parameters of the trail are similar (76 to 274 EUR per meter). The cheapest realization is even in similar price range, as much cheaper and easily built gravel roads (88 EUR per meter).

Discussion

Several design manuals and building codes are used in other countries. In British Columbia, the suggested minimum width is 1.5 m (Ministry of Tourism a Sport and the Arts British Columbia 2008), similarly, 1.5 m and 2.43m for the heavily used trails can be considered in planning policy of the Gallatin County (Gallatin County Planning Department 2001). Trails in our study are considered to narrow even by these standards. The cross-slope is in all cases of crowned trails said to be at least 3 % which is consistent with our findings except for the stone base trail, where minimum used was 1 %. This is probably because the structure of the stone base rail is made to drain through, and the need to divert the water of the crown, is not crucial as with different surfaces. Pavement structure is not specified in abovementioned standards. Partial structure requirements were set in Breckenridge (Town of Breckenridge 2007) trail standard, but are still very simple, leaving huge freedom to the designer. In comparison, surface types used and presented in this study are more complex.

Conclusions

We have shown the commonly used designs for trails in the national park. Even though the price was known for most of the projects, we did not include the calculations of the price per meter, as it depends heavily on the accessibility and allowed mechanization. The shown designs cover most of the possible situations and offer the choice for land owners to adjust them to their requirements and possible building code limitations. The limitations of the Czech Republic were presented in the introduction as stated by the Czech technical norms.

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USING GRAVIMETRIC METHOD FOR SOIL MOISTURE DETERMINATION

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Abstract

Knowledge about soil water content is essential for research in the field of agriculture, horticulture, forestry, ecology, water management, hydrology, construction, waste management and other environmental sciences. Water present within the soil pores is called soil water content. There are many methods used for soil water content measurements which can be divided into direct methods when soil moisture is measured directly from soil or indirect methods that are based on the measurement of another property which is dependent on soil moisture. One of the most common direct methods of soil water determination is gravimetric method. By the gravimetric method, soil moisture is determined from soil samples of known weight or volume after drying in the oven. The article presents the findings of soil moisture measurements from soil samples by gravimetric method at the experimental site Dolná Malanta. Soil sampling was realised during vegetation period of growing maize crop in the year 2017. The main goal of this article was to interpret the influence of biochar and N fertilizer on the water content in the top layer of the soil and analyse these changes. We focused on four variants in the experiment: control variant without biochar and N fertilizer (B0+N0), variant with biochar at dose 20 t/ha without N fertilizer (B20+N0), variant with biochar at dose 20 t/ha and N fertilizer at dose 160 kg/ha (B20+N160) and variant with biochar at dose 20 t/ha and N fertilizer at dose 240 kg/ha (B20+N240). We could not clearly prove the positive impact of biochar on soil moisture in 2017. Although, the water content was higher in B20+N240 there was not a big difference compared to the control variant.

Keywords: biochar, soil moisture, gravimetric method

Introduction

In the agriculture domain nowadays, emphasis is placed upon soil improvement through biochar application. Biochar is a charcoal made from biomass via pyrolysis used as a soil amendment. Pyrolysis temperature ranges between 300-1000 °C in the absence of oxygen. Biochar application was discussed in major agricultural textbooks and scientific journals and developed into a commercial product. Biochar was used in various fields for example as a soil additive improving soil fertility, crop yields, water regime and aeration of soils, for long-term carbon sequestration in soils, to decrease nitrous oxide emissions from soils or for electricity production (Antunes et al., 2017; Shakley et al., 2016; Lehmann et al., 2015; Jeffery et al., 2015; Spokas, 2010).

Attention to study the impact of biochar application in the field conditions was paid by many authors while examining the effects of biochar on greenhouse gas emissions (Horák et al., 2017), soil water regime (Igaz et al., 2015), other soil properties (Igaz et al., 2018; Juriga et al., 2018) and crop yields (Kondrlová et al., 2017; Kondrlová et al., 2018). Biochar application to agricultural soils has a significant potential to influence soil resource availability and thus crop performance. Although, positive effects of biochar application were proven, still there is a lack of studies in the scientific literature monitoring the effect of biochar in the field conditions. To contribute filling this gap, the following study was conducted aiming to interpret the influence of biochar and N fertilizer on the water content in the top layer of the agricultural soil and analyse these changes.

Material and methods

The experimental site of Slovak University of Agriculture located in Dolná Malanta in Nitra region of Slovakia was established in 2014. The area of interest was used for agricultural production and research purposes and it was sown by maize *(Zea mays* L.*)* in 2017. According to Igaz et al. (2015) biochar for this field experiment was produced from paper fibre sludge and grain husks by pyrolysis at 550 °C for 30 minutes in a Pyreg reactor (Pyreg GmbH, Dörth, Germany) and applied into the top layer of the soil (0-10 cm) in 2014.

Sampling is a critical stage in any research. We executed soil sampling on four variants in the experiment: control variant without biochar and N fertilizer (B0+N0), variant with biochar at dose 20 t/ha without N fertilizer (B20+N0), variant with biochar at dose 20 t/ha and N fertilizer at dose 160 kg/ha (B20+N160) and variant with biochar at dose 20 t/ha and N fertilizer at dose 240 kg/ha (B20+N240). Undisturbed soil samples (100 cm^3) were taken from desired depth at 3 randomly selected locations at plots representing each of 4 variants for determination of gravimetric water content (GWC) and volumetric water content (VWC), respectively once per week during two month period (April and May 2017) and once a month during the rest of the vegetation period of maize (June to October 2017). We should specify that all of the variants are founded in 3 replications at the experimental site in Malanta however this study was conducted within one replicate. For better interpretation of the results we should do further analysis on all of the replications and statistically evaluate the results. The soil samples were kept in air tight closed containers to prevent losses of moisture prior measurement in laboratory. The soil samples were weighed and dried in an oven at 105 °C (Fig 1). After removing from oven and slow cooling to room temperature, the dry soil samples were weighed again. The moisture content in the soil was calculated by specific formulas (1) and (2). The amount of water or moisture in soils can be measured as either GWC or VWC. Difference between GWC and VWC is that GWC is related to the mass of water and soil, whereas VWC is related to the volume of water and soil in the soil sample (Antal et al., 2012).

Figure 1 Drying undisturbed soil samples (left) in the oven at 105 °C (right). Disturbed soil samples in the image left were not related to this study

GWC is the mass of water per mass of dry soil in a given sample:

$$GWC\ \% = \frac{m_w}{m_s} = \frac{m_1 - m_2}{m_2}\ x\ 100 \quad (1)$$

VWC is the volume of water per volume of soil in a given sample:

$$VWC\ \% = \frac{V_w}{V_t} = \frac{(m_1 - m_2)\ x\ \rho_w}{V_t}\ x\ 100 \quad (2)$$

where:
m_w – mass of water (g)
m_s – mass of dry soil (g)
m_1 – weight of wet soil (g)
m_2 – weight of dry soil (g)
V_w – volume of soil water (cm^3)
V_t – volume of soil sample (cm^3)
ρ_w – soil water density ($g.cm^{-3}$)

Results and discussion

Analyses were based on own measurements at four variants of the field experiment B0+N0, B20+N0, B20+N160 and B20+N240 during the maze growing season in 2017. Measuring results for GWC and VWC and observed changes in water content trends are shown in Table 1. Figure 2 and Figure 3 present courses in the volumetric water content and gravimetric water content, respectively for different variants during the maize vegetation season in 2017.

Table 1 Measured values of VWC (% vol.) and GWC (% mass)

		April				May					June	July	Aug.	Sep.	Oct.
		03.	**10.**	**21.**	**24.**	**03.**	**09.**	**15.**	**22.**	**29.**	**29.**	**18.**	**14.**	**05.**	**10.**
B0+N0	VWC	28.17	30.15	29.13	29.31	30.80	29.94	30.23	28.05	26.71	19.53	20.77	15.13	14.74	29.23
	GWC	16.58	18.49	17.63	18.28	18.67	17.76	17.68	16.63	16.24	11.92	12.53	10.21	11.29	17.49
B20+N0	VWC	28.55	28.48	28.43	29.74	30.89	30.03	27.66	23.51	21.51	16.96	21.44	15.17	12.93	28.27
	GWC	17.69	17.45	17.65	18.09	19.26	18.17	16.64	14.96	14.24	11.37	13.33	10.20	10.27	17.06
B20+N160	VWC	27.66	29.41	27.83	29.23	30.88	29.43	28.40	24.13	25.84	17.23	21.91	17.66	15.58	27.25
	GWC	16.86	17.63	17.37	17.46	18.17	17.42	17.09	15.23	15.91	11.23	14.00	11.77	12.28	16.75
B20+N240	VWC	27.71	29.88	28.55	28.41	30.78	30.45	29.36	28.44	26.48	19.97	21.08	17.25	16.99	28.33
	GWC	17.24	17.57	18.14	18.33	18.83	18.05	17.99	17.33	15.36	12.47	13.13	10.44	12.23	17.99

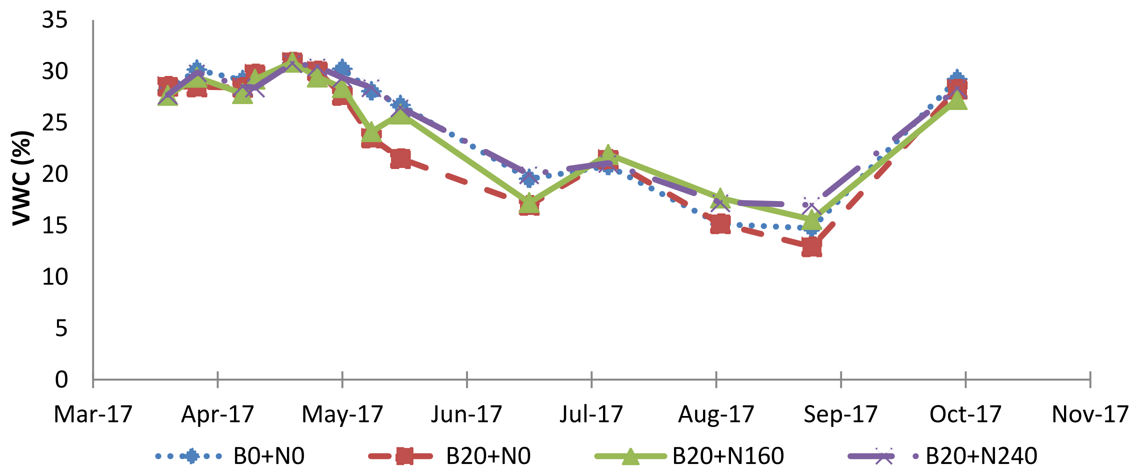

Figure 2 Graphical course of volumetric water content

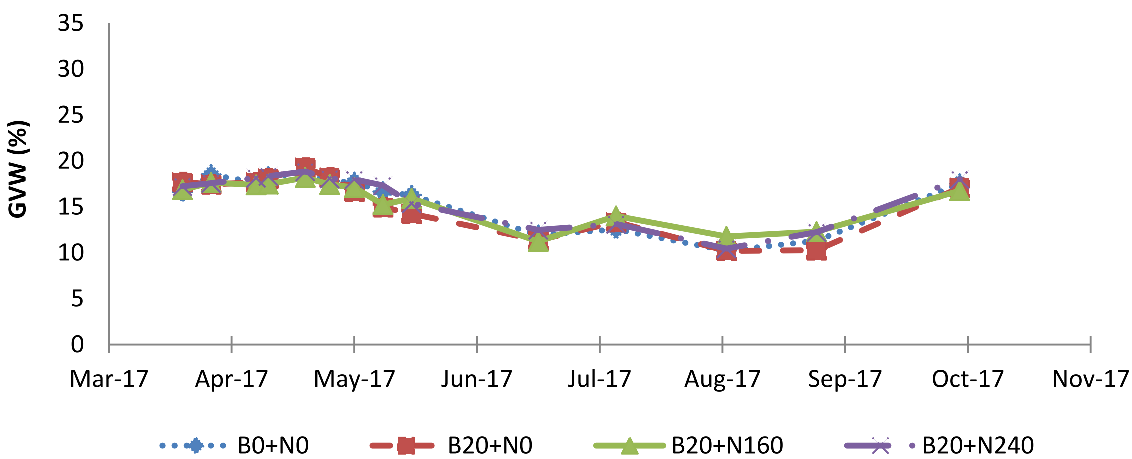

Figure 3 Graphical course of gravimetric water content

The average values of volumetric soil moisture for the whole period of grown crop were 25.85% for B0+N0, 24.54% for B20+N0, 25.71% for B20+N160 and 25.98% for B20+N240. The average values of gravimetric soil moisture were 15.81% for B0+N0, 15.46% for B20+N0, 15.66% for B20+N160 and 16.08% for B20+N240.

Climatic conditions especially influence of the air temperature and precipitation must be considered too. The average monthly values of temperature and precipitation are shown in Tab 2 as observed at the meteorological station Dolná Malanta. The average annual air temperature was 7.9° C and the annual precipitation was 489 mm in 2017. Graphical courses of volumetric water content changes according to Tab 1 with daily precipitation are shown in Fig 4.

Table 2 Precipitation totals and average monthly air temperature at Dolná Malanta in 2017

	Month											
	I.	**II.**	**III.**	**IV.**	**V.**	**VI.**	**VII.**	**VIII.**	**IX.**	**X.**	**XI.**	**XII.**
Precipitation (mm)	12.8	26.4	20.6	27.2	21.8	32.6	74.0	24.0	89.4	48.2	36.2	75.8
Temperature (°C)	-9.1	0.1	6.2	7.0	13.4	18.3	18.3	19.9	12.0	8.1	2.2	-1.1

As it is shown in Fig 4, at the beginning of the vegetation period the moisture was kept at high levels in the range of 25-30% vol. then it was decreasing until July. In the period June-July, the values of soil moisture in B20+N0 were markedly lower as compared to other variants. We assume that due to considerable high precipitation (74 mm) in July soil moisture increased up to 22 %vol. (B20+N160). In the following month soil moisture has dropped which may be due to summer air temperature raise. In September and October values of soil moisture are began rise. Throughout the vegetation period, the highest values were reached in B20+N240, but there was not big difference as compared to control variant B0+N0.

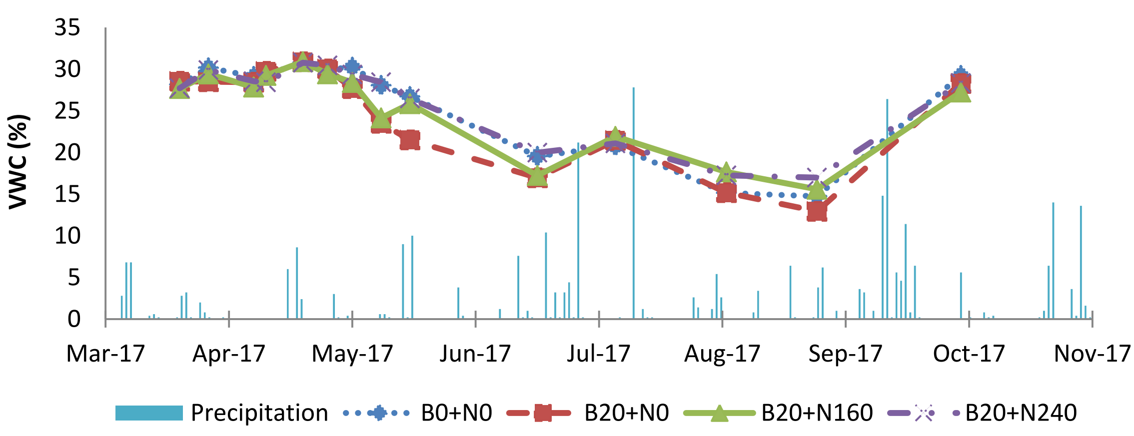

Figure 4 Graphical course of soil moisture changes with daily precipitation

Water content in the soil can range in relatively wide extent from completely dry soil to the value of soil porosity at full saturation of soil pores. The availability of water retained in the soil is essential for crop growth. In the natural landscape the soil water content depends on many variables such as soil type, climate and also the soil water regime. When soil moisture falls below the wilting point, plants struggle to survive. Similarly, too much of water in the can be threatening for plants. Soil water available to plants can crudely be estimated according to the soil texture. In the case of our experiment, the research was conducted on the loamy sand soil. According to Antal et al. (2014) available water for plants is computed as the difference between field capacity which is between 25-36% vol. and wilting point which is between 11-17% vol. If we look again in Fig. 4, we can see that the soil moisture values were within the range of available water to plants during the whole growing season of maize crop.

Conclusions

The article presents findings on influence of biochar application in different doses on the most important hydro-physical soil property which is soil moisture. Soil moisture expresses a proportion of liquid phase in the soil and its measurements are very important in many areas. We can conclude that the impact of biochar on soil water content in the third year since the establishment of experiment was equivocal. One of the reasons might be soil cultivation and subsequent incorporation of biochar into deeper layers of soil profile due to agro technical measures.

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VIRTUAL REALITY, TOOL FOR LANDSCAPE ARCHITECTS

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Abstract

Landscape architects use hand drawing or computer rendered visualizations as common form of client presentation. Making several pictures in more points of view takes a long time and makes presentation output seem static. Nowadays, we can choose more sophisticated way of dynamic project presentation – Virtual reality (VR). Despite the fact that virtual reality has existed for a few decades, the era of massive utilization starts now. People and architects especially, try to mediate feeling of their ideas that, in fact, doesn't exist. For an example of landscape study project we use software Unity 3D called "*Game Engine*". As the name indicates, a game industry uses these engines primarily in game developing. There is some user friendly software with VR technology support on the market, however functions are constrained. In the Unity 3D we show potential ways of its application in landscape architecture, as a great tool for landscape architects with high potential of usage.

Keywords: Virtual Reality, Landscape Architecture, Game Engine

Introduction

In past, using computer technologies in architecture was considered uncreative redrawing of architects' designs. Today the situation is reversed. Technologies are primary tools and their development is dynamic. We design and make 3D models of objects in virtual reality that become real projects and implementations. Žára (2010) explains that VR comes from science-fiction films to researchers', technicians' and regular users' computer screens. Most of us don't think about the opposite meaning of words virtual and reality. The base of VR is making environment models and scenes, their manipulations, movement in three-dimensional space and displaying them in real time.

But, what does it mean virtual reality? Every author has its own representation of the term Virtual reality. Aukstakalnis and Blatner (1994) describe virtual reality as a display of difficult information, manipulation and person's interaction with using the computer. Žára (2000) writes that VR is an environment that makes working 3D space and modelling in computer's memory possible. Virtual reality according to Daintith and Martin (2010, In: Vincúr, 2017) is a form of computer simulation in which the user has an impression of artificial environment. The user wears a helmet with two small screens on it, one for each eye. That creates a three-dimensional view of the computer generated environment. Sensors in the helmet detect head movements and they change the perspective of the scene. It is possible to wear data-gloves with sensors. By using hands in data-gloves user can move objects in the environment. VR systems are used for training purposes and fun. Winkler (2009) describes VR as modern term that determines three dimensional simulation of real objects and landscape by computer. Artificial worlds created by computer are often called cyberspace.

Figure 1 Virtual reality diveces (Author, 2017)

Nowadays VR offers a wide spectrum of usage for amusement, culture-educational, technical, scientific, medical and projection activities in building and landscape architecture. Limiting factors of virtual reality are available technology and human imagination only.

We can find examples of computer technology in PC games or in amusement park. People are willing to pay big money for the escape from the real world. The truth is that amusement is the most profitable application of VR. The virtual reality begins to be used in various fields of medicine. Next example of VR usage is culture-educational process where students can ask “what if…” questions and then verify them. Physics is a field where “what if” is a very common question. Houston University’s and NASA Johnson Space Center’s employees develop system called Virtual Physical Laboratory. The goal of the project was to create a possibility for students to conduct experiments in simulated laboratory and to handle the physical properties. In projection activity we can lower the costs by VR utilization. University in North Carolina, USA assessed the Sitterson Hall building project by VR technology before its development. During virtual walking they discovered some small issues of the project, which an architect could adjust with minimal cost. These changes in the finished building would be nearly unthinkable (Aukstakalnis and Blatner, 1994). According to Mengots (2016), interactive landscape visualizations are reviewed at the end of the design process rather than used as the communication tool between designer and stakeholder across the whole creation process.

The mentioned technology has a high potential of utilization and the future development in **landscape architecture**.

According to Kubišta (2011), nowadays it is possible to think about virtual reality implementation in **historical greenery reconstruction**. As he writes, VR could be used in the indication method of reconstruction. The goal of indication method isn’t fully-fledged return of the object into a composition, however because of the value of an object its reminding is expedient. VR offers powerful visual perception and virtual experience directly in environment of historical greenery.

We can use VR for client **presentation of landscape architecture study** the same way as in historical greenery reconstruction. The main benefit is that we focus on the client’s decision for own walking directions around the object as well as for object’s top view. This technology offers confrontation of the study and its changes before building.

Other interesting option of VR application writes Jančura (2005), where **visual impact** evaluation presents an identification of factors which signalize unfavorable changes in landscape. Visual impact has two demonstrations. First one is undesirable change in whole landscape structure whereby its composition is disturbed, for example by big homogenous areas, dull arrangement of surfaces and textures. The second demonstration is undesirable properties of objects which occur in landscape.

The light occurrence is inevitable requirement for real life perception by human eyes. Shading is objects representation by colorful shades which naturally arise at curved surfaces and give us better picture about them. In the computer modeling, simulations, animations and virtual reality the cast shadow plays very important function in spatial perception of person (Moravčík, 2009). In the field of landscape architecture **shadow mapping** can have significant influence. The sun – a light source, changes its location from east to west as well as in different angle depending of year season – winter / summer. Thanks to simulation of sun motion we can observe the time of eclipsing or dazzling on selected place.

Objects in 3D space we express in three dimensions X, Y, Z meaning that they have width, length and height. If these objects are time variable, we can use VR technology for **object changing in time** and simulate changes of sizes or textures. In field of landscape architecture could be a tree as an example of application. Accessible technology offers to us a simulation of a growing and tree evolution, its curving, leaf area, texture changing, as well as changing of aboveground and underground parts of tree during its life cycle. Result of simulation could confirm or not confirm a suitability of specific species' application on the place because of building interference alternatively root system interference into engineering meshes.

Material and methods

Material for purposes of this article contains a few hardware and software devices.

First of all we needed cadaster map, map background of interested area with contour lines for topography modelling and study design map.

Making of project we realized in desktop computer with subsequent hardware and software equipment: Processor AMD Phantom A6, 8 GB RAM, GPU Nvidia GTX and 500 GB Hard disk. Desktop computer runs on regular Windows 7 64 bit.

Basic lines and contours of our project we drew in **Autodesk AutoCAD 2016** with student license. AutoCAD is part of CAD software (Computer Aided Design) with easy and powerful drawing environment. Software's input is mostly used DWG file.

3D modelling was a job of **Trimble SketchUp Pro 2014**. It is due to the easiest modeling software on the market. With very good community support, 3D objects and plug-ins is SketchUp great tool for rendering of picture visualizations too. SKP file is a basic input of software.

Unity is a 3D game authoring tool for Mac and PC. Game engines are the nuts and bolts that sit behind the scenes of every video game. From the artwork right down to the mathematics that decide every frame on screen, the "engine" makes the decisions. Starting out with rendering—the method of displaying graphics on screen, and integrating a control method and a set of rules for the game to follow—the engine is what a developer builds to "house" the game. Modern 3D game engines are a deluge of meticulously written code, and as such, once used for their intended purpose (which is the production of a game they are made for), these engines are often sold, modified, and reused. An obvious example of this is the Epic Games Unreal Engine. Originally developed in the late 90s for Unreal—a PC First Person Shooter—the engine has gone on to see massive success in its more recent incarnations, being licensed by other developers for literally hundreds of commercial games and simulations (Goldstone, 2009). Unity workspace is split into four boxes. *Hierarchy* located left above shows open objects in the scene. In the box *Scene / Game* is displayed object. There we can rotate around the object or move in a random direction. On the right side of monitor is situated *Inspector* box, a place of assorting of object's attributes. Underneath of screen we find out *Project* box – library of scenes, materials, models, scripts. Users certainly can adjust workspace to theirs demands.

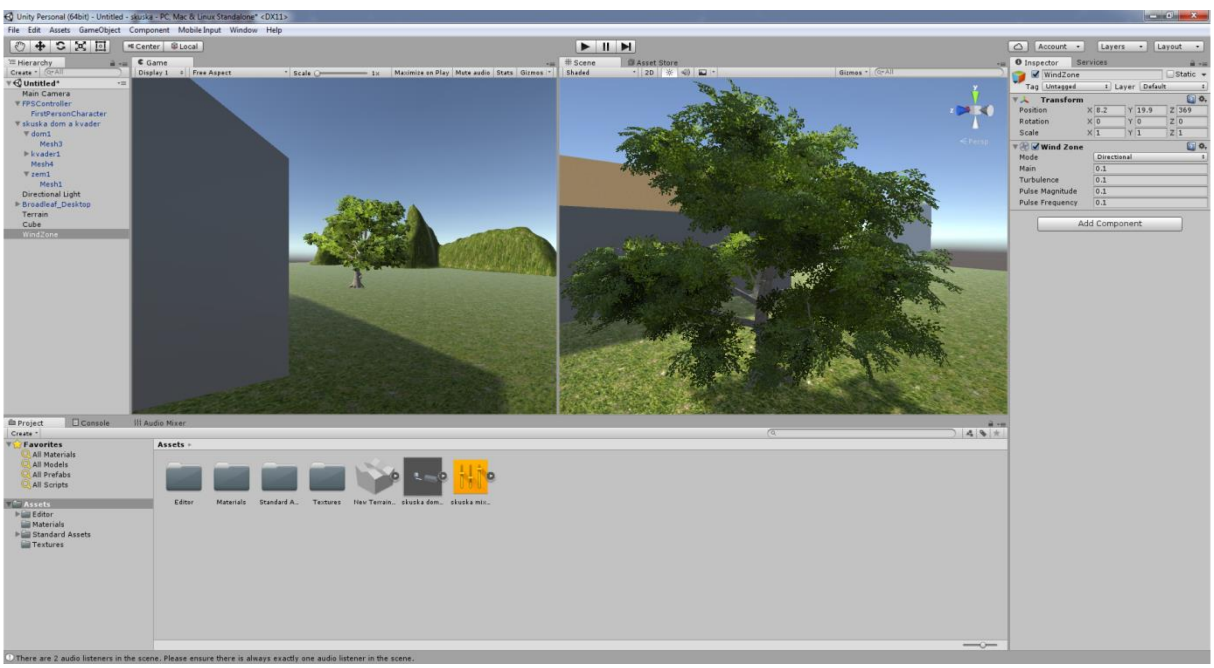

Figure 2 Unity 3D Workspace (Author, 2019)

Presented **method** is divided into two parts – modelling and application of virtual reality. If you have a 3D model of object, you can leave out first part of method – modelling and continue with second one.

As a background of presented method we used landscape architecture study of pond near the village of Veľké Zálužie. The village is located 12 km far from city of Nitra, western Slovakia.

In the first part of method we digitally drew selected region. Thanks to cover of cadaster map with contour lines we redrew them in polyline form in AutoCAD. Whole contour lines got their altitude. To the basic digital map we inserted floor plan of landscape architecture study. AutoCAD's DWG file was imported to the software SketchUp. This easy tool for modelling offered us to create 3D models of whole object by a simple way. Thanks to contour lines selecting and application of *From Contours* tool a terrain was built. In other SketchUp windows (scenes) we drew objects as fisher's cabins, a wood bridge, a mole house, footpaths and a barrage and afterwards imported to the right place by *Drape* tool into terrain model. Prepared digital model was exported in FBX file format (you can use COLLADA format too).

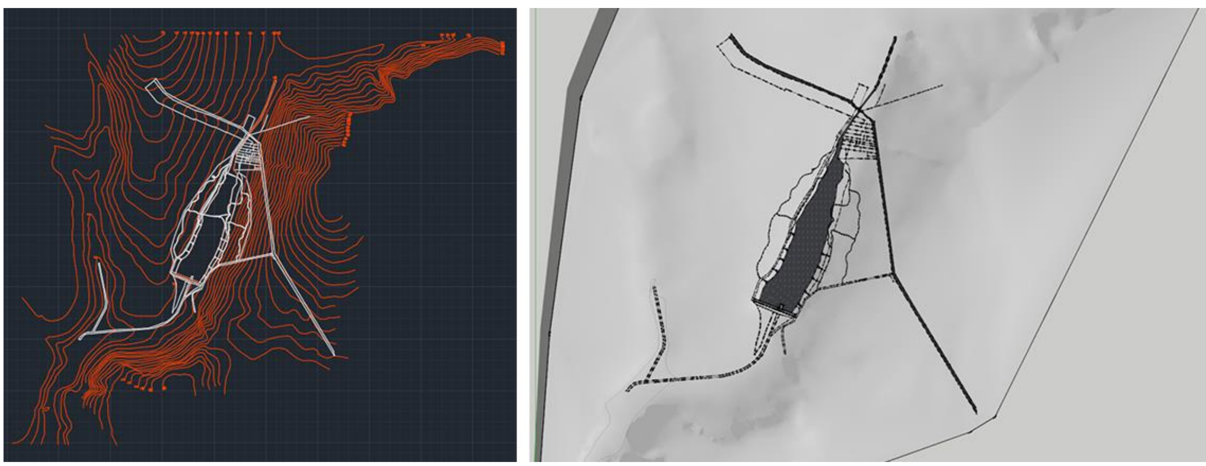

Figure 3 Project polylines in AutoCAD (left) and 3D terrain in SketchUp (right) (Author, 2019)

On the beginning of second part (application of virtual reality) FBX file of our study model was imported into game engine Unity 3D. Terrain with objects represents monochromatic mesh model into which we added sketchup generated textures for all model components. By reason of pond in the study, with the help of unity asset we filled water area. For working presentation it was important export unity scene into EXE file.

Results and discussion

Our goal we focused for three options of virtual reality using in landscape architecture in this article – study presentation, visual impact and object changing in time.

3D model in Unity we used for landscape architecture **study presentation**. In the model we had to add greenery. Unity 3D software offers two species of trees, which we inserted to the model as well as our own tree built in the engine. In that we focused to dynamic representation we offered to clients an ability to walk around by themselves. In Unity 3D we set a view called *First person controller* wherewith clients can walk and see an environment from eyes height same as in video game. Virtual mesh environment got physical attribute *Mesh Collider > Physic > Zero Friction* what means *FPC* (first person controller) can walk on virtual terrain. Exported EXE file you can open on any computer.

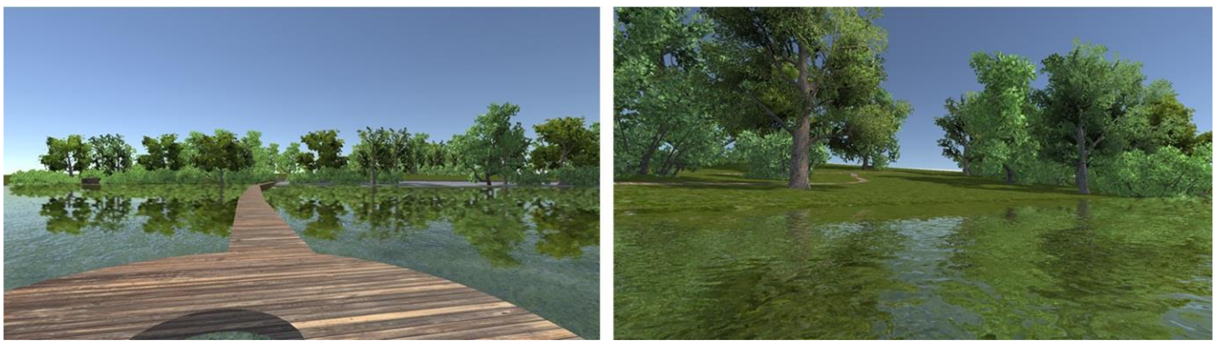

Figure 4 Screenshots from walking in Unity 3D (Author, 2019)

Another alternative of virtual reality using is **visual impact** presentation where we used Unity 3D game engine. We continued on the base of study presentation model. We decided to focus on the side-walk across the pond as a visual impact object. We had to implement two buttons (On/Off) with which we are able to switch on / off the side-walk. Thanks to built-in software Monodevelop Unity we could program buttons into the project in C# language. Programmed code

```
EnableDisable.cs
No selection
using UnityEngine;
using System.Collections;

public class EnableDisable : MonoBehaviour
{   public GameObject Enable_Disable ;
    public void Enable()
    {
        Enable_Disable.SetActive (true);
    }
    public void Disable()
    {
        Enable_Disable.SetActive (false);
    }

}
```

Figure 5 *Programing in Monodevelop Unity (Author, 2017)* was inserted as component into *GameObject*. Side-walk represented by *Mesh13* in our project we inserted to *GameObject > Script* as the object. Exported project is ready for use. Now the side-walk can be switch on or switch off by buttons On/Off on the screen.

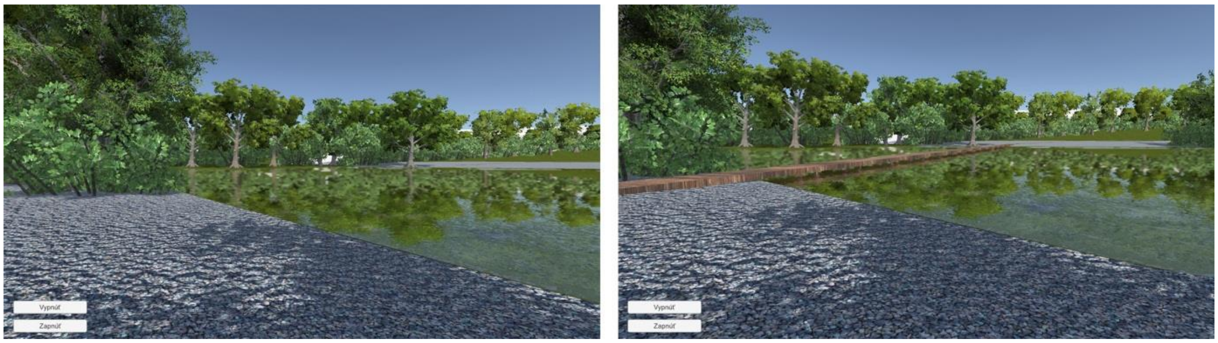

Figure 6 Visual impact - side-walk (Author, 2019)

In the landscape architecture study tree was created by us. We again used Unity 3D which offers ability of **object changing in time**. Into new Unity scene we imported Tree generator-application of plant simulation, especially trees. Tree is made by couple levels. First one is a trunk on which branches growth up to third level. As the last level we applied leafs and texture of leaf on them. Trunk got bark texture as well as branches. Finished tree was imported by *Window > Animation* for tree growing simulation. By the help of keyframes we adjusted adult high of tree at the end of 10 seconds animation. Finished animation was exported in EXE file where you can watch growing of this tree.

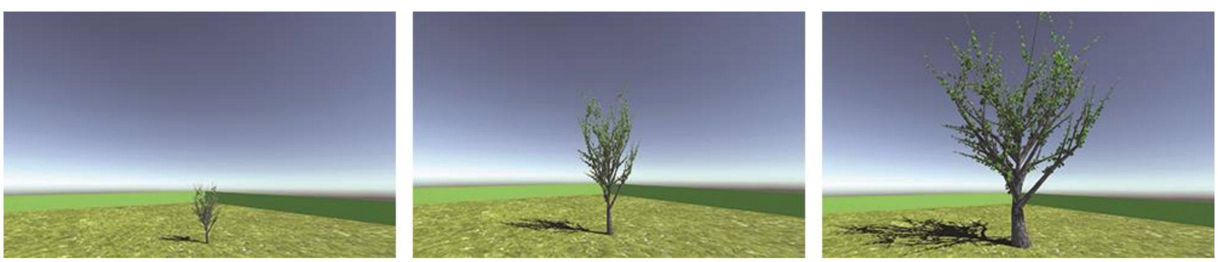

Figure 7 Tree growing simulation (Author, 2019)

We can say that we used basic available software in the whole creating process of the terrain model: AutoCAD and SketchUp. We didn't try other drawing programs in this case. Virtual reality application we presented in free version of Unity 3D. Presented technique aims to bring people new option in perception of virtual landscape and environment impacts. According to

Thompson and Horne (2006), VR models are great tools to support public understanding of environmental characteristics and to allow debate on landscape issues.

Conclusions

In our paper we presented couple options of using of virtual reality in the field of landscape architecture. Frequently used basic software AutoCAD and SketchUp were complemented by Unity 3D - game engine in this case. We can confirm game engine is great tool in presented two options. In the study presentation client can walk by himself over landscape model. Unity 3D can be used in presentation of visual impact in environment however some programming skills must be there. Our animation of tree growing didn't carry off. It doesn't represent growth of real tree. With more software skills and complemented tree details it could be good basic of tree growing observation for students for example.

Acknowledgment

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CAN REDUCED ROTATION PERIOD REDUCE THE RISK OF BARK-BEETLE DISTURBANCE IN TEMPERATE FORESTS? – PRELIMINARY RESULTS

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Abstract

The rotation period of spruce exceeds 100 years in many European countries makes forests rather vulnerable to both wind and bark beetles. We used the process-based landscape-scale forest disturbance model iLand to simulate wind and bark beetle disturbances and different forest management practices. The aim of our study is to evaluate effects of reduced rotation period on the amounts of trees killed by bark beetles and windstorms. The study is conducted in a managed temperate forest landscape in Central Europe in the Low Tatras Mountains with stands dominated by Norway spruce. We simulated the impact of six windstorms during the 200-year simulation period, and the subsequent bark beetle outbreaks. We simulated forest development under the business-as-usual rotation period and under the rotation period reduced by 10, 20 and 30 percent. We found that shorter rotations efficiently reduced the mean age of the forest. Following this reduction, amount of breeding material for bark beetles was reduced as well and the amount of disturbed trees decreased. We revealed complex patterns of changing forest vulnerability under different rotation period, which can inform forest management on how to optimally reduce the impact of forest disturbances.

Keywords: forest management, Ips typographus, wind, iLand, disturbances

Introduction

The most damaging biotic agent in European forests is *Ips typographus* (L.) in terms of both damaged timber volume and affected area. The European spruce bark beetle attacks mainly spruces with age above 60 years. Most of bark beetle outbreaks in central Europe were triggered by wind disturbances, which also impact more severely older forests. Therefore, substantial resources are invested into clearing the windthrow areas and sanitation fellings. The question of efficiency and purpose of phytosanitary measures and procedures that can prevent forest stands from these huge wind and bark beetle disturbances stays open (Wermelinger, 2004).

Disturbances intensity has increased in recent decades and this trend will likely continue in the future. Activity of European spruce bark beetle will be higher and with increasing temperatures the outbreaks may shift to higher latitudes and elevations (Hlásny et al., 2011). Overall the effects of climate change on the bark beetle disturbances will increase their frequency by directly affecting their development with temperature change and indirectly with changing species composition, the amount of windthrown trees and the stress level of potential host trees (Thom et al., 2017).

Bark beetle impacts can be mitigated by reducing the availability of host trees and older trees which are particularly susceptible to attack.

The rotation period of Norway spruce currently exceeds 100 years in a number of European countries. The reduced rotation is therefore increasingly examined as a powerful means to reduce forest vulnerability and adapt the forest to intensifying disturbances (Klimo et al., 2000).

The rotation period (rotation length) is a key parameter in management of even-aged forests. It is defined as time elapsed between two final clearcuts in the forest stand. The main management goal in forestry is usually production of wood so the optimal length of rotation period is driven by economic requirements in combination with productivity factors as volume growth, age of trees, time period available for colonization by some species (Roberge et al., 2016). The shortening of rotations can significantly decrease availability of production trees to some key habitat components. If the fellings are made more often it prevents production trees from becoming large and through this becoming vulnerable for bark beetles and windstorms too. But that means they are not providing large amounts of wood material for economical purposes (Felton et al., 2017). Another question with shortening rotation period is the carbon stored in the forest. The shorter rotation and intensification of thinnings causes reduction in carbon stored in trees, so the change in carbon pools should be another valuable component in making decisions of forest managers (Zanchi et al., 2014).

Reduction of rotation period can be powerful tool of management to decrease forest vulnerability to wind and bark beetle disturbances. Nevertheless, this approach is not actively exploited in disturbance management, where productivity indicators as still of key importance. Moreover, this approach may interfere with other management objectives, i.e. nature

conservation or size and distribution of trees and thus also the timber production. Knowledge of how modified harvesting regimes affect disturbances in forest landscape are not complete yet (Chen et al., 2017).
Here we investigate a long-term impact of reducing the rotation period as a powerful mean in forest management and its impact on temperate forest landscape with managed production forest with dominance of Norway spruce. The aim of the study is to find impact patterns of reduced rotation periods on the forest stand with disturbance agents. The study should investigate the change in bark beetle damaged volume and windthrown volume and the response of tree mean age.

Material and methods

The study region is located in Slovakia in the Low Tatras Mountains in the central Europe. The region is covered by forest stands in 70% of 16 000 ha large area where the Norway spruce (*Picea abies* (L.) Karst.) dominates the species composition with almost 70%. Forest stands are used there for timber production and so they are under the intensive management procedures. In recent years the area has been under the influence of severe bark beetle and wind disturbances. The intensive disturbance activity affected nearly 40% of the forest area in years 1996-2010 (Dobor et al., 2018).
We use here the process-based landscape-scale forest disturbance model iLand (Seidl et al., 2012). This model was developed to simulate dynamic of forest landscape, its ecosystem processes and their interactions across spatial and temporal scales. The basis in the model is individual tree with defined processes of growth, mortality and regeneration (Seidl et al., 2012). Bark beetle disturbance submodel is simulating development of beetles considering their development, dispersal, colonization, overwintering and other components of the beetle phenology all dependent on temperature changes (Seidl and Rammer, 2017). The wind disturbance module works with external wind data from climate models or meteorological observations. iLand simulates the wind exposure according to the size of gap and the shelter from the neighbour trees (Seidl et al., 2014). Connecting these two disturbance models allow us to simulate both types of disturbances and even the bark beetle disturbances triggered by wind.
The forest development and bark beetle dynamics in time period of 200 years were evaluated. We run simulations with the default rotation period and for every rotation reduction. The effect of 6 wind events with different windspeeds, directions and durations was simulated. This events were distributed in simulation years 25, 50, 80, 110, 140 and 170. Each wind event triggered the bark beetle outbreak. We run simulations with the rotation period under the business-as-usual

taken as default and then we had runs with the reduced rotation period. We reduce rotation period by 10 %, 20 % and 30 % difference from the default one.

Results and discussion

The amount of harvested volume increased with the reduced rotation because harvests were being conducted more often. The shorter rotations cause decrease in mean age of the trees, as trees were cut earlier in their life cycle. At the default simulation the mean age was 60 years. The rotation shorter by 30% caused decrease in the mean age to 47 years old forest stand. Specifically, the reduction of rotation period by 10% caused decrease in mean age by 8.8% and by 30% reduction decreased the mean age up to 21%. (Table 1). The mean tree age for reduced rotations distinctly decreased in the first two decades compared with the default rotation. Reduction by 30% caused intensive decrease in the mean age of the trees and the values remained low for the whole 200 years period (Figure 1a).

Table 1 The simulated values of selected forest development indicators reached under the default rotation period and three alternative rotation period. For reduced rotation period, absolute values and percent difference from the default rotation are indicated. The table show average values over the 200-year simulation period.

	Default rotation	**Reduced by 10%**	**Reduced by 20%**	**Reduced by 30%**
Harvest	1071.1	1171.4 (+9.4%)	1308.5 (+22.2%)	1422.6 (+32.8%)
Bark beetle damage	0.81	0.74 (-8.4%)	0.67 (-17.5%)	0.66 (-18.7%)
Wind damage	1.79	1.71 (-4.9%)	1.51 (-15.6%)	1.39 (-22.7%)
Spruce volume	246.02	230.97 (-6.1%)	219.42 (-10.8%)	211.51 (-12%)
Mean age	60.07	54.77 (-8.8%)	50.51 (-15.9%)	47.55 (-20.8%)

We found that rotation reduction by 10% caused the reduction of stands with age below 60 years and thus the amount of material suitable for bark beetle infestation decreased. This caused the decrease in the amount of volume disturbed by bark beetles. With reduction by 20% there is by 17.5% less bark beetle damage volume and reduction by 30% can cause to 18.7% less bark beetle damaged volume compared to values reached under the default rotation period (Table 1).

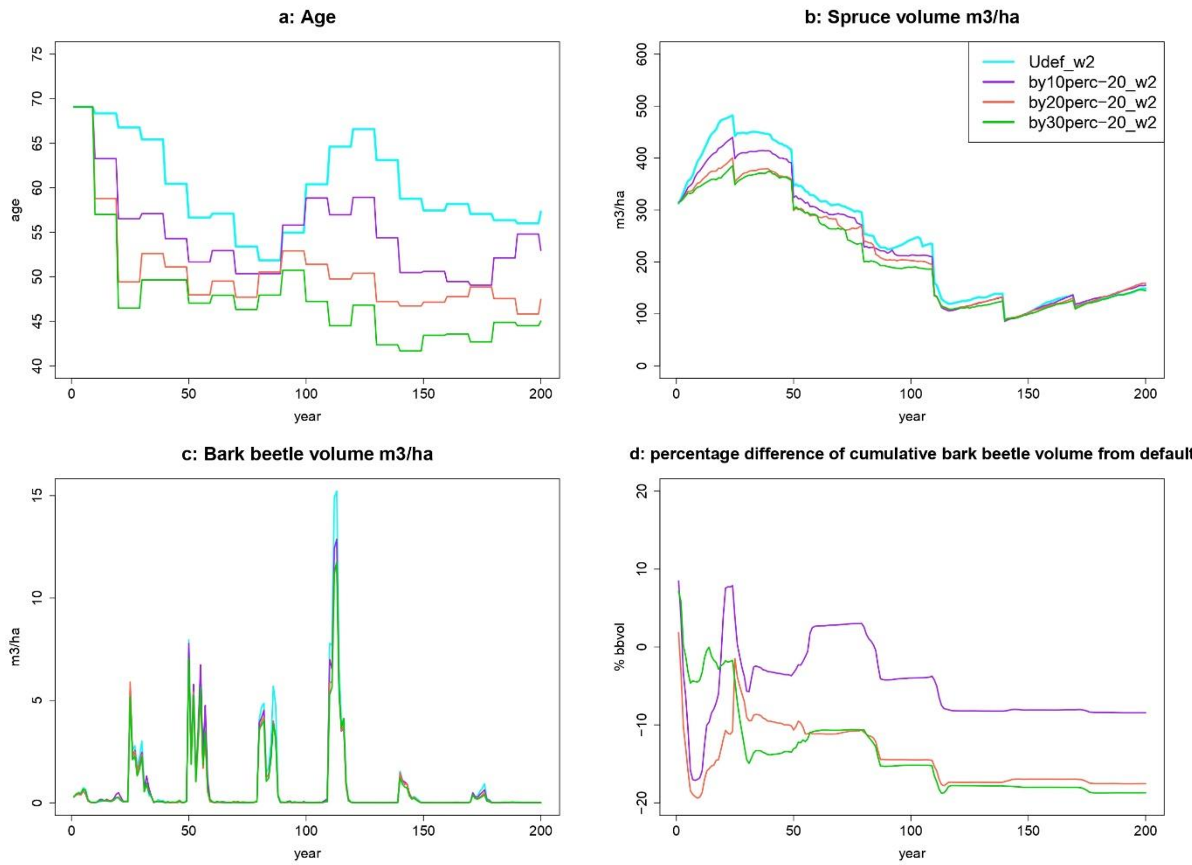

Figure 1 Change in mean stand age, spruce volume, bark beetle–killedvolume and percentage difference of cumulative bark beetle volume compared to the default rotation period. Simulation outputs for the 200-year simulation period are shown.

In the Bark beetle volume plot (Figure 1c) we can see six main peaks of bark beetle outbreaks in years after the wind storms. After the years 140 and 170 of the simulation we have just small outbreaks. The reason for them to not get to higher values is the amount of suitable infestation material. The amount of spruce trees is reduced with time for the whole simulation period and with not enough breeding material the bark beetle outbreaks can't be launched as huge as with forest composition dominated with spruce (Figure 1b). Shorter rotation length is thus reducing the forest vulnerability also to wind disturbance agent (Table 1). Bark beetle disturbances were significantly reduced by reduced rotation period, and this effect was as much as 20%. The percent difference in second decade is, however, largely influenced by the decreasing volume of spruce in the landscape and therefore the overall bark beetle disturbance decreased as well (Figure1d).

Here presented findings suggest that reduction of rotation lengths is viable adaptive response to climate change and increasing disturbance rate (Felton et al., 2016; Roberge et al., 2016). Shortening rotation periods seems might be further option to reduce bark beetle damages with its effect of particularly reducing susceptible stand development phases (Seidl et al., 2009; Spiecker, 2003). The study of Valinger and Fridman (2011) indicate that the shorter rotations also can reduce the risk of wind damage which is the same result, that our simulations showed. Due to increased risks of disturbance events the motivation to harvest trees in earlier stage of growth can be strengthen in conditions of climate change (Bergh et al., 2010; Felton et al., 2017, 2016).

However, the positive influence of reduced rotation period on disturbances can have some undesired effects on biodiversity conservation objectives, such as the loss of specific habitat features (Felton et al., 2017). Shorter rotation period can also support more flexible management with quicker responses to environment changes and requirements of the market (Nakajima et al., 2017). As Zanchi et al. (2014) say it can reduce amount of spruce growing stock and the primary productivity. In the long run it can cause lower wood production and thus negatively affect economic purposes in high intensity management forests.

Conclusions

Shortening of rotation lengths will significantly reduce the mean age of forest. Thereby the suitable breeding material for spruce bark beetle is reduced too and it causes decrease of tree volume damaged by bark beetles. Rejuvenation of trees also reduces forest vulnerability to wind impacts.

This study revealed that the rotation reduction can be powerful tool to control forest susceptibility to diverse disturbances and particularly to bark beetle attacks. These information can serve to forest managers in setting optimal rotation period that would not consider only the productivity but also hazard indicators.

Acknowledgment

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POSTER SECTION

Detecting erosion-induced geomorphic change in small- to medium-sized agricultural catchments (Fugnitz, Austria; Nitra, Slovakia) using Terrestrial Laserscanning (TLS) and Structure from Motion (SfM) techniques

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Introduction and Objectives

In small- to medium-scale soil erosion and connectivity studies, high resolution surface models are needed to detect geomorphic change and to take into account (micro-)topography. The aim of this study is **to detect geomorphic surface change along linear erosion structures** in two highly dynamic agricultural catchments with two techniques: **Terrestrial Laserscanning (TLS) and Structure from Motion (SfM).** Both approaches are then being compared in the following contexts: **accuracy, validity, and applicability.**

Study Areas

For detecting linear erosion structures, two catchments with comparable environmental settings were chosen: The Fugnitz catchment (Fig.1, left) and the Bocegaj-catchment (Fig. 1, right).

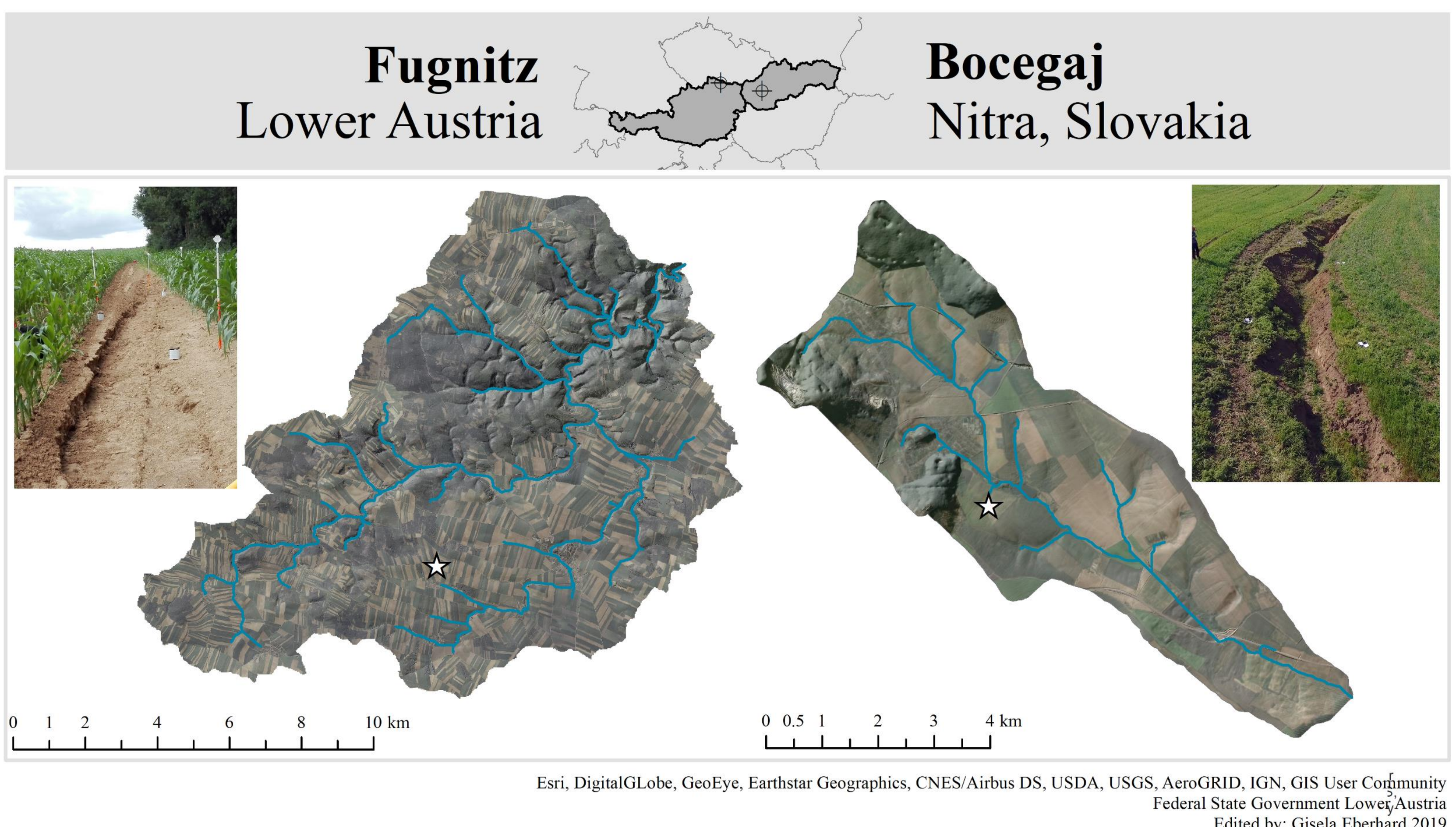

Fig. 1: Study areas in Lower Austria (Fugnitz; left) and Slovakia (Bocegaj, right)

- Size: 138 km²
- Mean annual temp.: 8,3°C
- Annual precipitation: 600 mm
- Soils: podzols, cambisols
- Landcover: forest and arable land
- Relief: hilly (steep slopes in forested areas)

(PÖPPL 2010)

- Size: 34 km²
- Mean annual temperature: 9,8°
- Annual precipitation: 539 mm
- Soils: luvisols, cambisols, fluvisols
- Landcover: forest and arable land
- Relief: hilly (steep slopes in forested areas)

(KATELOVA et al. 2014)

Methods

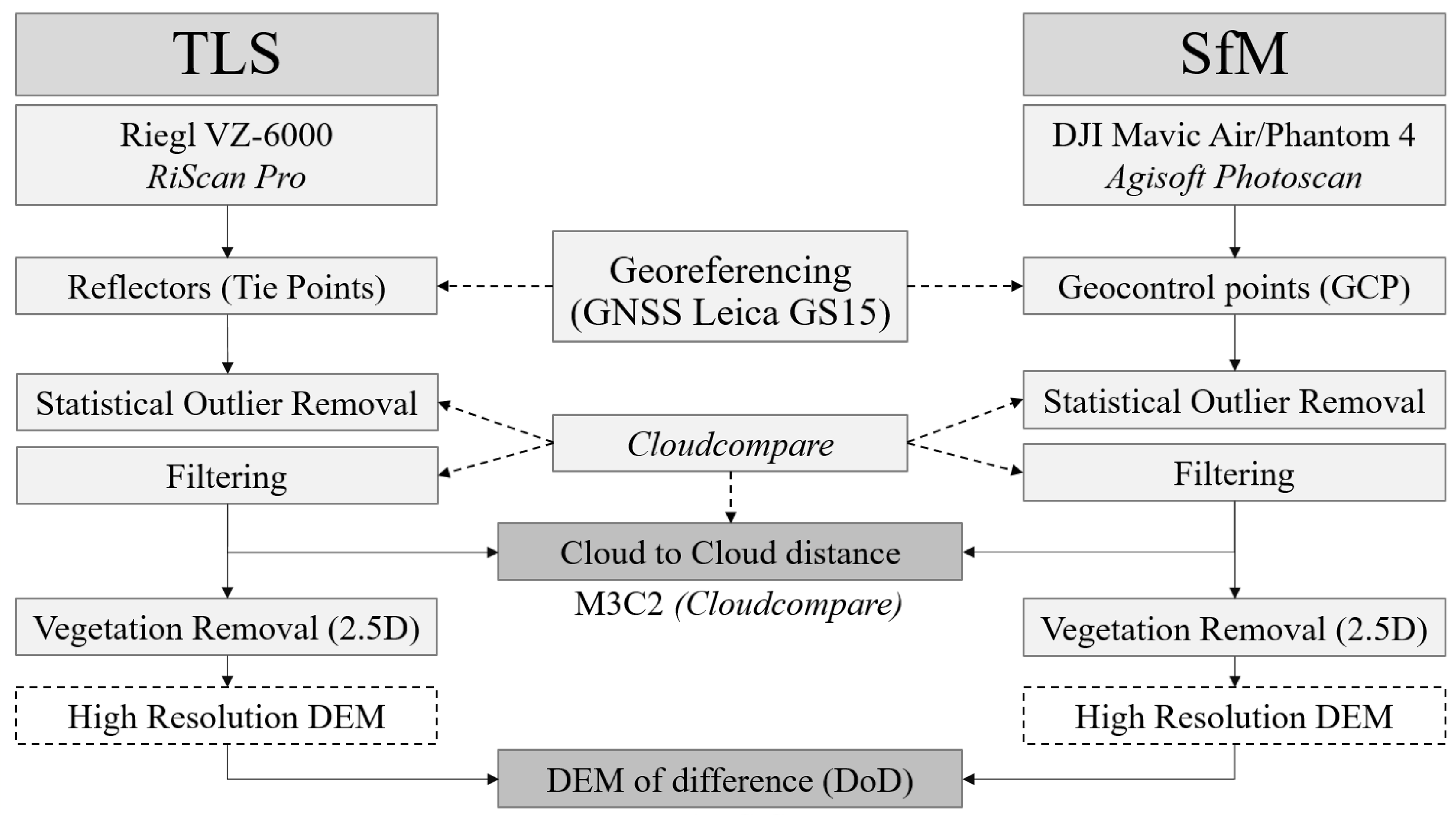

Fig. 2: Step-by-step methodology

Preliminary results (Fugnitz, Lower Austria)

- **Similar erosion pattern** of TLS and SfM data
- Main differences at the **southern part** of the rill
- DoD TLS: volumetric overall soil loss of **1.117 m³**
- DoD SfM: volumetric overall soil loss of **1.232 m³**
- **Areas of deposition are negligible** (SfM < 0.018m; TLS < 0.02m)

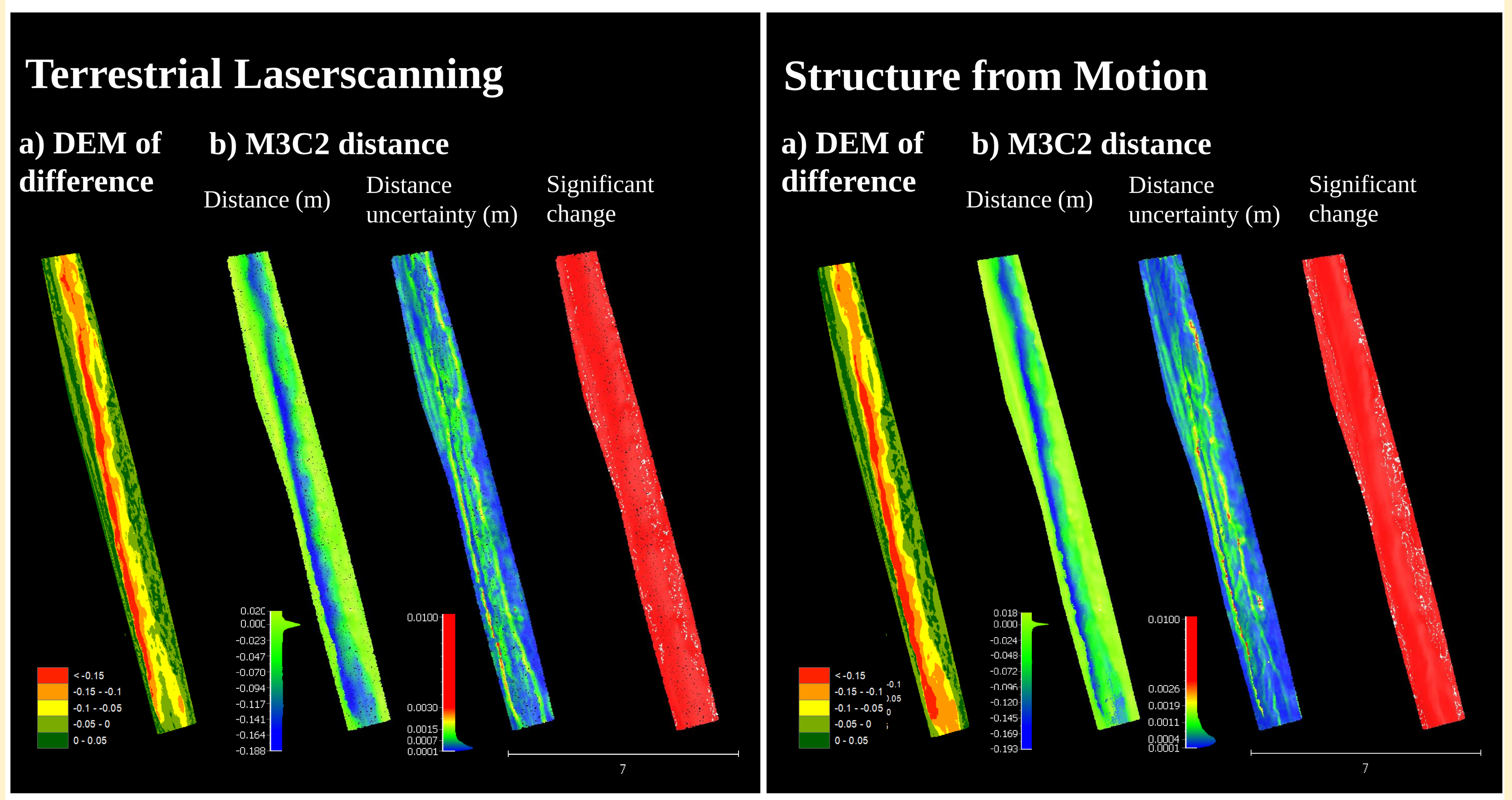

Fig. 3: Geomorphic change detection with DEM of difference and M3C2 distance calculation: Terrestrial Laserscanning (left) and Structure from Motion (right), Fugnitz catchment (Lower Austria)

Preliminary results (Bocegaj, Slovakia)

- **Deposition mainly along the rill floor** in both TLS and SfM data
- **Erosion patterns strongly differ** in TLS and SfM datasets (especially along the rill sidewalls in the central and southern part of the gully)
- DoD SfM Added volume: **(+)2.197 m³**; Removed volume: **(-)1.948 m³**
- DoD TLS: Added volume: **(+)1.673 m³**; Removed volume: **(-)1.219 m³**
- Distance uncertainty of TLS data **much lower** than of SfM data

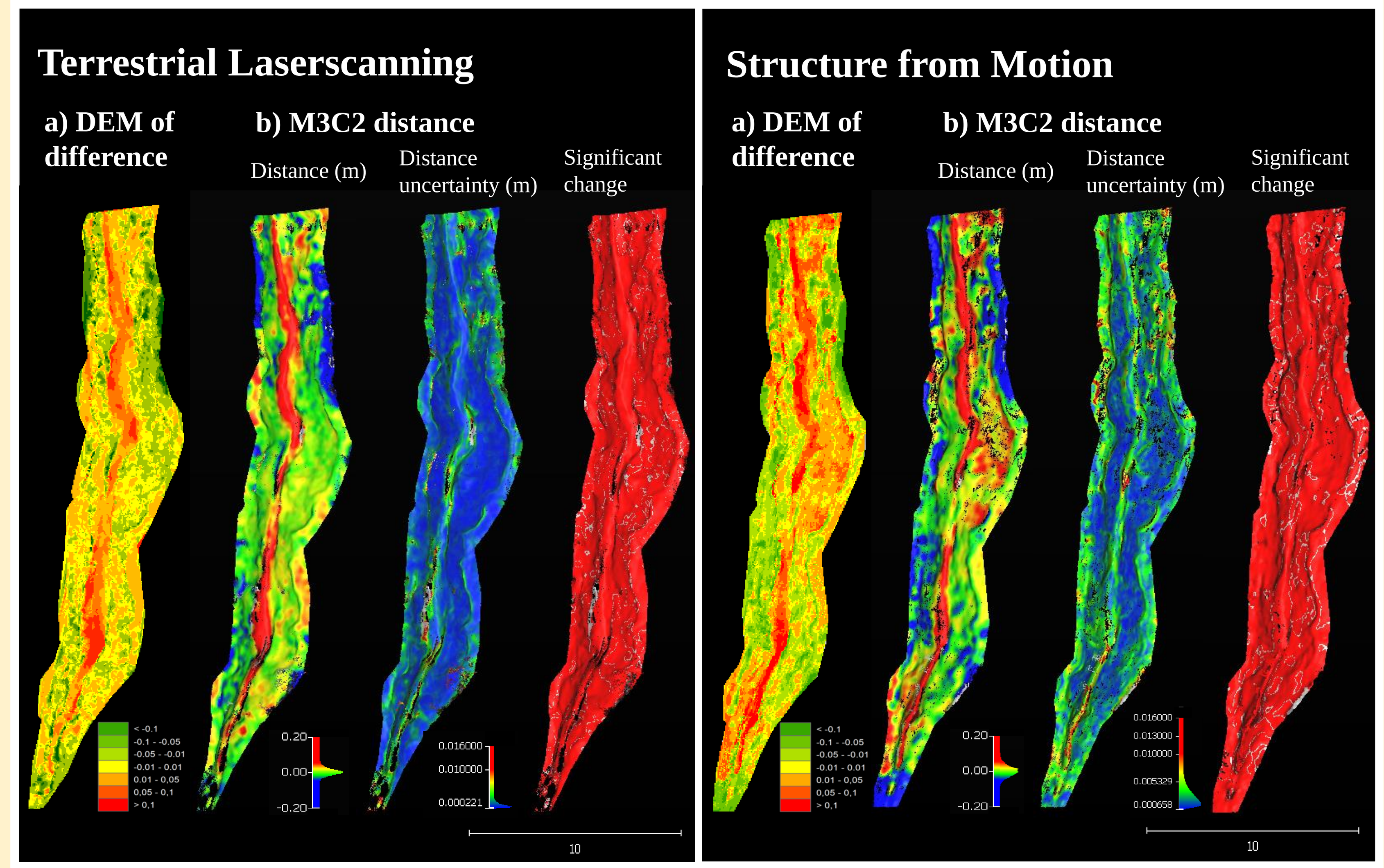

Fig. 4: Geomorphic change detection with DEM of difference and M3C2 distance calculation: Terrestrial Laserscanning (left) and Structure from Motion (right), Bocegaj catchment (Nitra, Slovakia)

Discussion, Conclusion & Outlook

- M3C2 distance calculation is **more sensitive to vegetation** in SfM than in TLS data, leading to the results of notably higher surface change
- DoD calculation of SfM and TLS data demonstrate **strong differences**, even with lowest point detection at a cell size of 0.05
- **Volumetric surface change strongly differs** between TLS and SfM data, even if vegetation is limited, which can be attributed to **vertical structures or overhanging parts**
- Further research is done in **improving data** and **removing vegetation**

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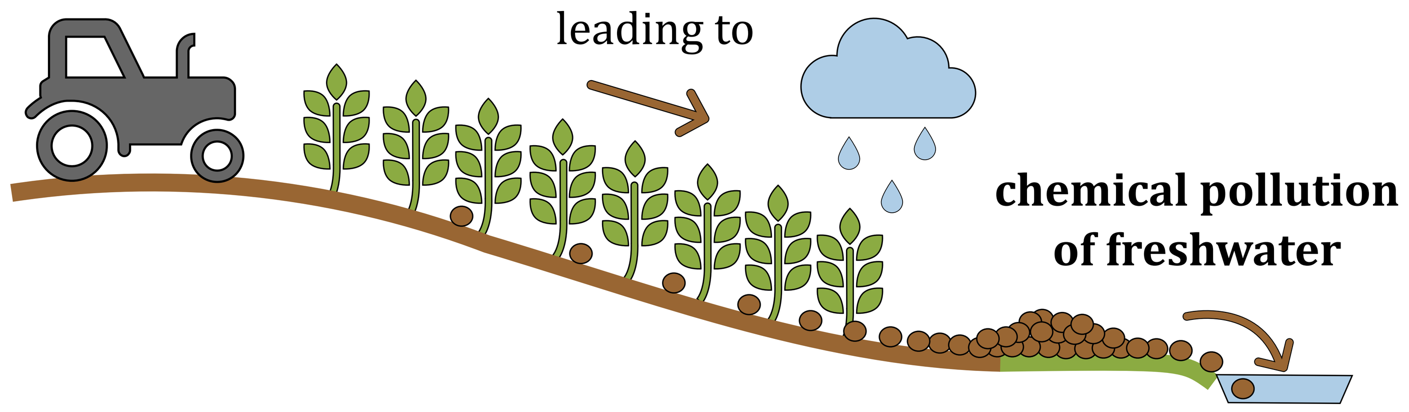
Effects of vegetated riparian buffer strips on lateral sediment input to agricultural river systems and the role of man-made linear flow paths

Lisa Humer[1], Gregor Luetzenburg[1], Gisela Eberhard[1], Ronald Poeppl[1]

Introduction

Heavily intesified soil erosion of arable land



High loads of fine sediment are transported to the channel via overland flow pathways, furthermore **man-made linear flow pathways** can drain substantial parts of a catchment. **Vegetated buffer strips** between arable fields and the river channel are a common mitigation measure, because they are trapping sediment. (HOESL et al. 2012)

Study Area

Fugnitz catchment
size: 138,4 km^2
total permanent channel network: 80 km
main stem: 29,7 km
annual precipitation rate: 550 mm
mean slope: 2,6°
mean discharge at outlet: ~ 0,5 m^3/s

The Fugnitz River in the north of Lower Austria is a 29.7 km long stream with a catchment area of 138.4 km^2. On Austrian territory the Fugnitz is the main tributary of the Thaya, the bordering river between Austria and the Czech Republic, where the **Thayatal National Park** is located. Recent studies on river ecosystem condition have shown, that the Fugnitz is in a **poor to moderate ecological state**, besides other factors being caused by high phosphorus concentrations caused by **lateral sediment-associated input** from arable fields. Vegetated buffer strips alongside permanent streams are eligible for subsidy in Austria, but not continously present along the Fugnitz and its tributaries. (POEPPL et al. 2012)

Research Questions

Among other factors such as event magnitude, buffer strip dimensions and characteristics - which are highly variable in the Fugnitz catchement - affect their **trapping efficiency**, further being subject to ongoing research. Furthermore, although vegetated buffer strips alongside perennial streams are a common mitigation measure in **catchment management**, the role of man-made linear flow paths in delivering sediment to streams is often overlooked. (HOESL et al. 2012) Motivated by these research gaps, the following research questions were formulated:

1. Do the existing **vegetated buffer strips** in the Fugnitz catchment prevent eroded agricultural fine sediment from reaching the river system?
2. Is the installation of vegetated buffer strips a **suitable management tool** to effectively prevent later fine sediment input?
   a) What is the role of the event magnitude?
   b) What is the role of field characteristics (eg. topography)?
   c) How does the vegetation structure of the buffer strip influence its capacity?
3. What is the **role of man-made linear flow paths** in the catchment in terms of sediment connectivity and fine sediment input?

Approach

1. Buffer Strip Analyses

volume of sediment in BS
vegetation height of BS
BS width
type of crop
precipitation rate with rain gauges
height of crop

Parameter investigation in the field

Scenario modelling with WEPP based on investigated hillslopes

2. Analyses of man-made linear flow paths

mapping of entry points in the field

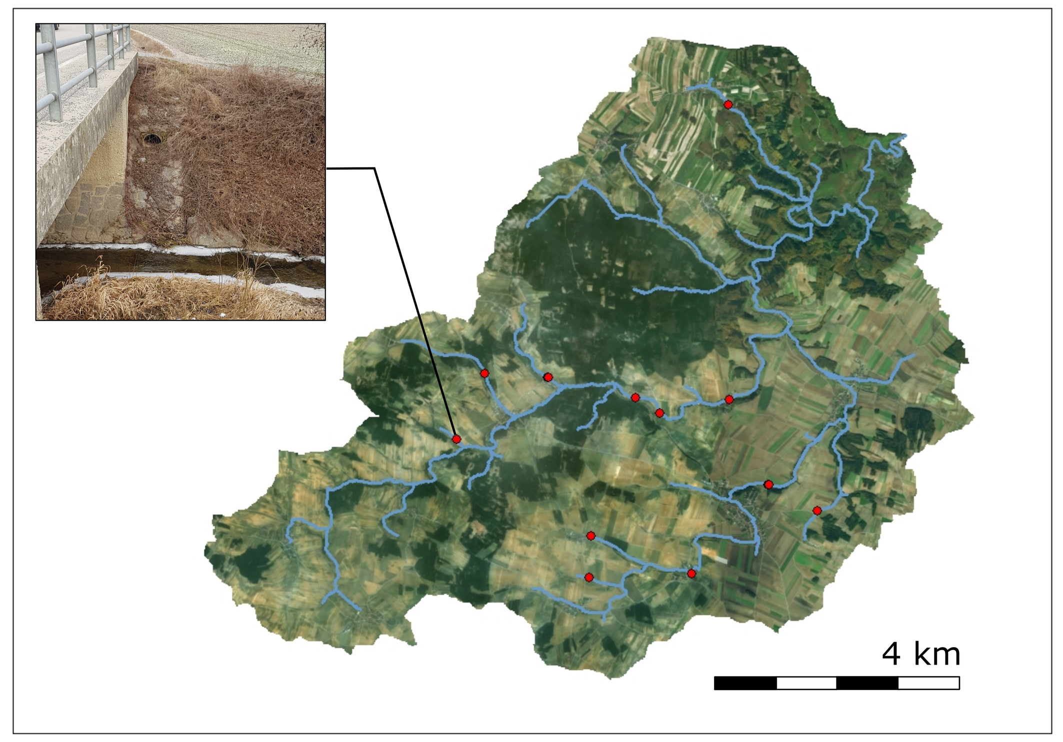
Investigation of potential soil loss & sediment yield with GeoWEPP

3. Evaluation of possible mitigation strategies

First Results

Average slope: 2°
Maximum slope: 10.6°
Slope length: 372 m
Field size: 3.9 ha
Cultivation: Maize
Height of cultivation: ~ 40cm
Buffer strip width: 4.5 m
Height BF Vegetation: ~30 cm
Sediment volume in BF: 2,18 m^3
Precipitation rate: **~ 35 mm in 1h**

The photos show one of six investigated buffer strips after a heavy rainfall event in June 2018. The amount of eroded sediment **exceeded the capacities** of all investigated buffer strips.



The connectivity mapping revealed **12 entry points** of man-made linear flow paths into the river channel system. Modelling the subcatchments of each entry point will show, how much of the area is draining through these points and how much **sediment potentially enters the river system** in this way.

Items to discuss

The work of this study is still in progress. The aim is to better understand **sediment connectivity** in the Fugnitz catchment in order to draft recommondations for **future sediment management**. Your questions and input are welcome!

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Key Literature:

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EVALUATION OF QUANTITATIVE PARAMETERS OF THE SOIL UNITS ON THE BASIS OF THE MODELING WATER EROSION IN THE BASIN OF THE RIVER MYJAVA, SLOVAKIA

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Introduction

Degradation of soil is a global problem. In Slovakia a significant threat represents the water erosion, which is caused by the impact of rain drops on the surface of the soil, and then by surface drainage (Petrovič et al., 2017). Water erosion spans a large area of agricultural land, causing degradation of the fertile layer of the soil and reduce the depth of soil profile.

Identify the affected areas or areas susceptible to soil erosion is the first step in implementing the anti-erosion measures (Muchová, Tárniková, 2015).

The protection of soil against water erosion, you can ensure well as organizational measures. One of such measures is the size of the soil units.

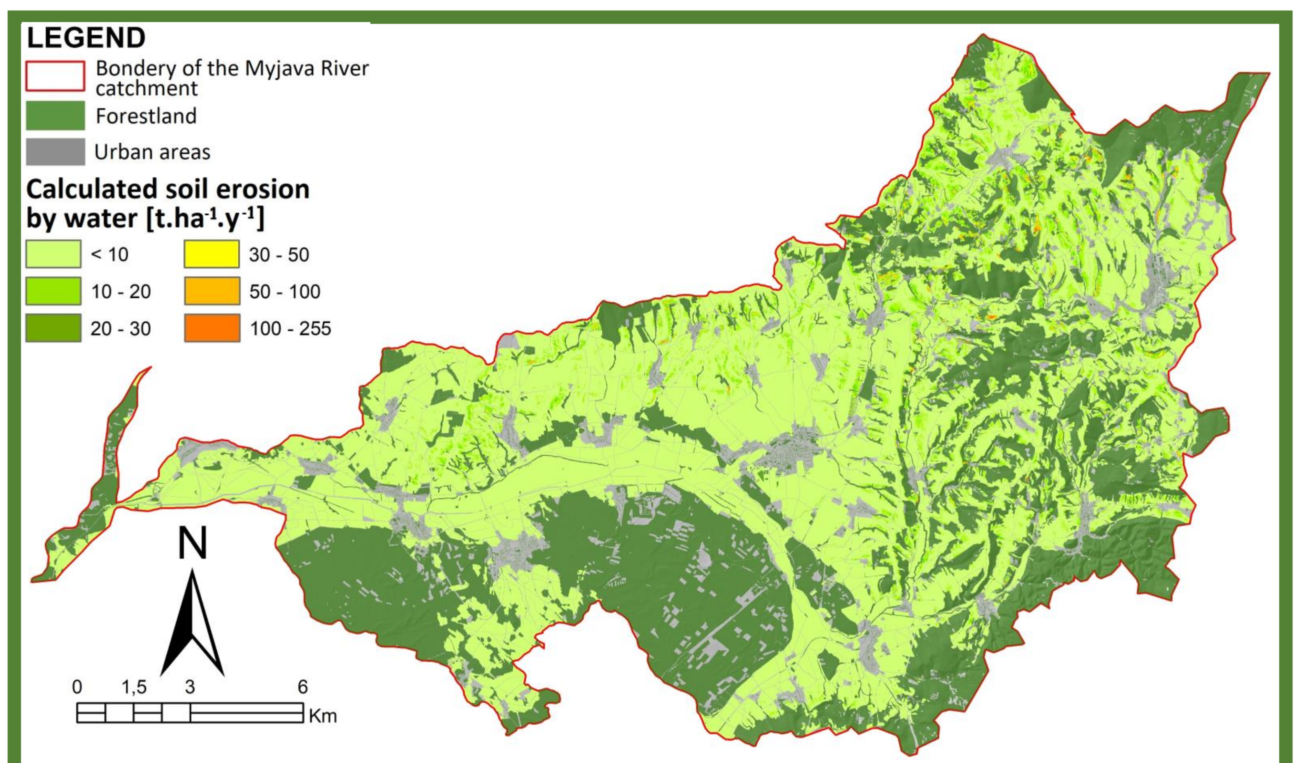
The objective of this contribution is to assess the compliance boundary criteria the size of the soil units of arable land according to the valid standards (STN 75 4501), to determine the intensity of water erosion on agricultural land using the universal equation of loss of soil (USLE) and to verify the impact of the current use of the countries on the intensity of water erosion. Propose the distribution of soil units, which do not meet the applicable standards and to evaluate the intensity of the loss of soil by the water erosion, after the proposal of the contraction of the soil units at the boundary values.

Material and methods

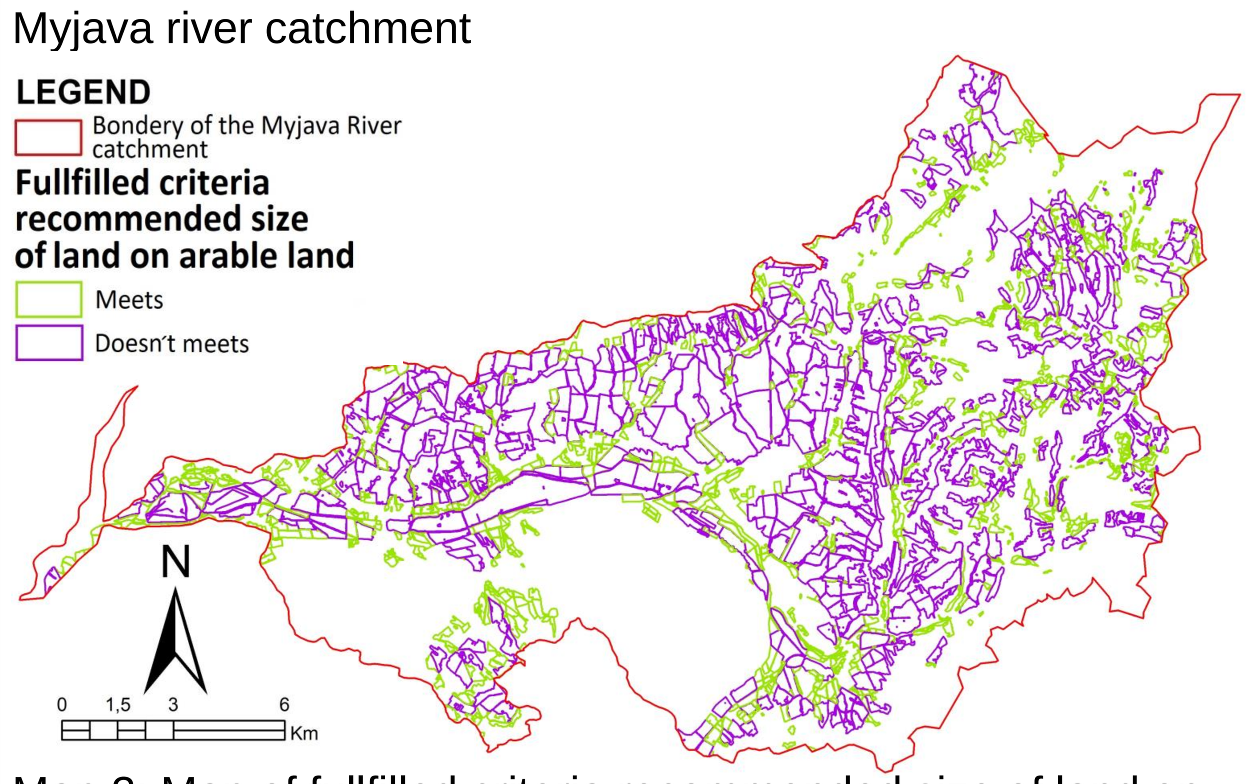
Area of interest - the basin of the river Myjava (4-13-03) is located in the Záhorie lowland in the whole Chvojnicka upland. Area of river basin extends to 54 of the cadastral territories. The boundary of the basin of the river Myjava was derived on the basis of the digital model of relief (DMR) generated from contours vectorised from the Base maps if Slovak in the scale 1: 10,000. For the development of the current land-use was used in the vector cadastral map (VKM) updated with use of the register of the land LPIS and ortophoto maps from the year 2017. For the evaluation of erosion hazard caused by water erosion has been used an empirical model based on the universal equation of loss of soil-USLE (Wischmeier and Smith, 1978). Applied model calculates the loss of soil in $t.ha^{-1}.year^{-1}$ as a result of the interaction of five factors. The equation has the form: SP = R . K . L . S . C . P ($t.ha^{-1}.year^{-1}$). To determine the R-factor were used the values from ombrografic records, which are listed in the work Ilavska et al. (2005). The K-factor to each of the main soil units in the model area was taken from the work Ilavska et al. (2005). The factor of length and gradient of the slope has been replaced by the topography of LS factor based on slope and length of slope. In the calculation of the LS factor to take into account the barriers, it is the existing water management and anti-erosion measures. The value of the LS factor was determined in the range of 0-131. The value of C-factor for individual elements of the current land-use are processed under the Alenu (1986) and were determined: 0.005 for grassland; 0.45 for orchards; 0.29 for arable land; 0.45 for the garden; 0.80 for the vineyard and field roads; 0.50 for non-forest vegetation. When determining the factor P was chosen the value 1 for the model area, since they were not available detailed information about spatial definition erosion control. From the tilt of the slope and the size of the soil units of arable land depend delimitation criteria for divided of arable land and permanent grassland (table 1).

Results and discussion

In the model area were differentiated 1,572 soil units of arable land. In the first slope categories (0-3°) were identified 668 (42.5%) of the soil units covering an area of 10,809.67 ha. The other categories (3-7°) 601 on the area of 15,972,48 ha, the third category (7-12°) 285 on the area of the 3,369.52 ha, and in the last category (>12°) were identified 18 soil units of arable land on the area 21.26 ha. On the basis of the calculation of the intensity of water erosion were soil units, agricultural land categorized by individual categories slope (map 1). In tab. 1 is referred to the recommended size of the soil units on arable land in terms of anti-erosion protection of soil and the area of soil units with a performance criteria the size of the individual soil units. The spatial arrangement of soil units is shown in map 2. From the analyses showed that the calculated loss of soil in the model the river basin is 88,377.75 t.the year $^{-1}$. Alarming is the finding that of the total estimated losses of land to 73,823.28 t.year $^{-1}$ (83.5 %) is formed on surfaces that do not meet the criteria of the size of the soil units. In the model area were these soil units of arable land spatially identified. Subsequently, they were, on the basis of the recommended size of the soil units with regard to map erosion threat territory, area optimized, i.e. reduced to the recommended size according to the categorized tendencies. Again it was the calculated loss of soil. In tab. 2 we present an overview of the results. The area of arable land decreased by 565 ha. This loss of arable land is caused by a change in the type of land in the fourth category slope (above 12°) on permanent grassland and the proposal of measures that we optimize the size parameters of the soil units.



Map 1: Map of calculated intensity of water erosion in the Myjava river catchment



Map 2: Map of fullfilled criteria recommended size of land on arable land in the Myjava river catchment.

Table 2: Recommended size of land on arable land in terms of erosion control according to STN 75 4501 and area land

Slope angle (°)	Recommended area of soil units (ha)	Area of Arable Land (ha)	Area of Arable Land (%)	Fullfilled criteria the size of the soil units	
				Meets (%)	Doesn't meet (%)
0-3	0-30	10,809.67	35.83	35.15	64.85
3-7	0-20	15,972.48	52.94	14.17	85.83
7-12	0-10	3,369.52	11.17	18.96	81.04
>12	Without the recommended size of the area	21.26	0.07	0.00	100.00
Entire Catchment		30,172.93	100.00	22.21	77.79

Table 2: Calculated intensity of water erosion in model river catchment related to slope of land in degrees and size of soil after application of soil size criteria

Slope angle (°)	Size of the soil units on arable land (ha)	Area of Arable Land (ha)	Mean Erosion ($t.ha^{-1}.year^{-1}$)	Annual Soil Loss ($t. rok^{-1}$)
0-3	0 – 30	10,622.07	0.444	4,712.29
3-7	0 – 20	15,865.86	3.408	54,073.37
7-12	0 – 10	3,119.52	5.464	17,044.26
>12	Change in the type of land on grassland	21.26	x	X
Entire Catchment		29,607.45		75,829.91

Conclusion

The aim of the paper was to point out the non-compliance of STN 75 4501. In the model area, up to 77.79% of the arable land plots does not meet the size criteria. In the current arable land management, annual soil loss is assumed to be 88,377.75 tons. For an area of 30,172.93 ha, where the size criteria are not met, land loss is estimated at 73,823.28 t. year $^{-1}$. By complying the plots of arable land size criterion, it is possible to estimate the reduction in annual soil loss by 12,547,84 t. year $^{-1}$.

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