THE COLOUR-FORMING COMPONENTS OF PARK LANDSCAPE AND THE FACTORS THAT INFLUENCE THE HUMAN PERCEPTION OF THE LANDSCAPE COLOURING

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Abstract
The colour theory research in the field of environmental colouristics was analyzed and systematized, in particular the variability of the landscape colouring. The article is presenting results of the seasonal analysis of colouring of the Kyiv parks (Ukraine) by the author's method of landscape colouring assessment. Also, the classification of factors that determine park landscape colouring has been formed, namely features of perception, climatic factors and park landscape components. Based on the results of park landscape colouring assessment, the hierarchical structure of colour-forming components and influence factors of perception in landscape colouring were formed and the interconnections between these factors were revealed.
Keywords: landscape colouring; colour assessment; seasonal dynamics; colour perception; park landscape components.

1. INTRODUCTION

Colour is a complex dynamic phenomenon, which depends on the light-colour-space environment in which it is located, and which determines the conditions of its perception (Matyushin, 1928). Such an approach to colour perception, in our opinion, is the most relevant for the colours study in the nature environment, as within it, it is rather not possible to separate colours. In accordance, park landscape

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colouring is a complex of park landscape colours in a certain period of time, which is determined by colours of landscape components and also colour-forming factors. The colouring is defined as the general coloration of the object or space that is formed as a result of the common effect of all colour composition components in perception, so, it is the total impression of all colours that create the composition at the same time (Abisheva, 2009). Park landscape colouring has a variable nature and changes throughout the day, year, and any longer period. An important aspect of landscape colouring study is the features of its perception, because colouring is eventually formed during this process. Colours are never perceived in isolation, but in their colourimetric characteristics that are changing (Hobhouse, 1985; Thorpert, Englund & Nielsen, 2018). Thus, the research of the landscape colouring can have two directions: object-oriented (focused on the study of landscape colour-forming factors) and subject-oriented (focused on human as a subject of perception and features of this process). In our research, attention is focused on determining the colour-forming factors of the park landscape and it is object-oriented.

Architects are frequently talking about creating an integral visually comfortable colour environment of architectural and natural objects of the city (Tarajko-Kowalska, 2012; Manav, 2017; Yilmaz, 2017). However, while implementing the concepts of organizing city colour environment a difficulty occurred: the lack of research about colour of landscape architecture objects (Bos, 2008; Thorpert et all, 2018) and factors of their formation.

The goal of our research is identification of colour-forming components of park landscape and factors which influence the colour perception of landscape, and also formation of their interconnection structure. The research was based on systematization of theoretical works and our own results of park landscape colouring assessment of the objects reaserched. The study of relationship between space environment elements is difficult, as they affect each other (Bakker, 2014). The complexity of systematizing the factors which create colouring of nature environment or influence the perception lies in their interpenetration. As per Stepanov (1985, p. 22) "Studying the aesthetic influence of colours, it is necessary to consider the laws of its multilateral direct and inverse connections. There are the colour and light, colour and 3-D form, colour and material, colour and function... these groups of interconnections are so closely combined that it is sometimes difficult to understand the difference between them."

2. THE OBJECTS AND METHODS OF THE RESEARCH

Peremoha Park, Slavy Park, Feofania Park, Taras Shevchenko Park, M. Rylsky Park in Holosiivo, "KPI" National Technical University of Ukraine Park are the objects of our research. They have different functionality, area, species of trees and shrubs, park composition and, accordingly, colouring.

The landscape colouring assessment was based on our own method (Gatalska and Mavko, 2012; Oleksiichenko and Mavko, 2013, 2015), that includes the following: photofixation of main park view-points during four seasons, processing these photos using graphic editors and determining main colours percentage in park landscape. Photo processing was carried out using the graphical editor "GIMP Image Manipulation Program".

3. RESEARCH RESULTS

According to the literature review (Matyushin, 1928; Bohovaya-Kapper, 1959; Minnaert, 1954; Stepanov, 1985; Bos, 2008; Abisheva, 2009) and Kyiv parks colour analysis results (Gatalska & Mavko, 2012; Oleksiichenko & Mavko, 2013, 2015; Oleksiichenko et all, 2017), we proposed the classification of factors and components that determine the colouring of the park landscape. Thus, the summation of colour-forming components of park space and influence factors of perception in landscape are divided into three main groups: the colour-forming components (components of the park landscape), optical factors and climatic factors (the latter two belong to the influence factors of perception). The optical factors are determined by the physiology of human eye optical system, which determine the visual angle: the outer limit of the field of visual perception is 166°, and the object remains visible at a distance that does not exceed its size in more than 3,500 times. The maximum distance of colour recognition, according to Panksenov (1988), is 2000 m in fair weather. The optimal vertical angle of perception is at 27°, and horizontal – 54° (Schmidt et al., 1970; Kurbatov, 1988; Oleksiichenko et al., 2017).

Another influence factors of landscape colouring perception is characteristic of the climate: the region's climate in general, weather conditions and illumination at the moment of contemplation. The own colours of the park landscape components (greenery, relief, building, garden furniture, water, etc.) directly form the park colouring. Accordingly, factors can be defined as objectively determined by biological nature of the object and subject of perception, so can not be changed, only taken into account. Colour-forming components of park landscape are formed during the design process and is determined by landscape architect (Figure 1).

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Group of optical factors are relatively stable because they are related to the structure of the eye optical system. Climatic factors are the most variable group, since they can change several times a day. The park landscape components are intermediate, they are biological objects, which determine their development in time and space, however this process is less dynamic than changeability of climatic factors.

The important aspect of park landscape colouring research is formation of hierarchical structure of colour-forming components and factors and determination of interrelationship between them (Figure 1). Accordingly, the park landscape components are basic, and the optical and climatic factors influence their perceptions and can be considered as special "filters".

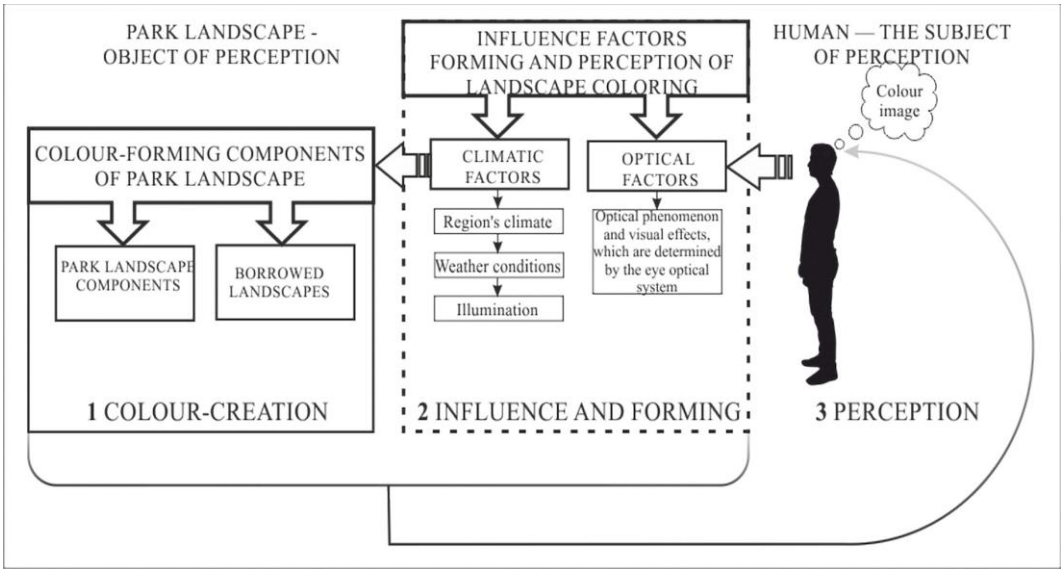

FIGURE 1 - HIERARCHICAL STRUCTURE OF COLOUR-FORMING COMPONENTS AND HUMAN FACTORS OF PERCEPTION OF PARK LANDSCAPE COLOURING

3.1. Optical factors

Among the optical factors, only those that are relevant in the perception of natural environment were selected, but not all the features of the perception (Figure 1). We didn't take into account the defects of colour vision, but only normal colour perception. Since research is focused on the object-oriented approach, as well we didn't take into account the psychological properties of perception, the aesthetic preferences of observers, etc.

Based on an analysis of the existing literature on space perception and our research results, we have identified the following optical factors: effect of chromatic stereoscopy, aerial (atmospheric) perspective, Tyndall effect, additive colour mixing, simultaneous contrast, effect of colour irradiation, glare, Purkinje

shift, Aubert phenomenon. Some of chosen optical phenomena will be described further down, with the colour-creating factors which they are related to (Figure 2).

Thus, the interconnections of optical factors with other groups of factors are important because they may be revealed in different conditions and should be taken into account as their influence on colour perception in natural environment is significant.

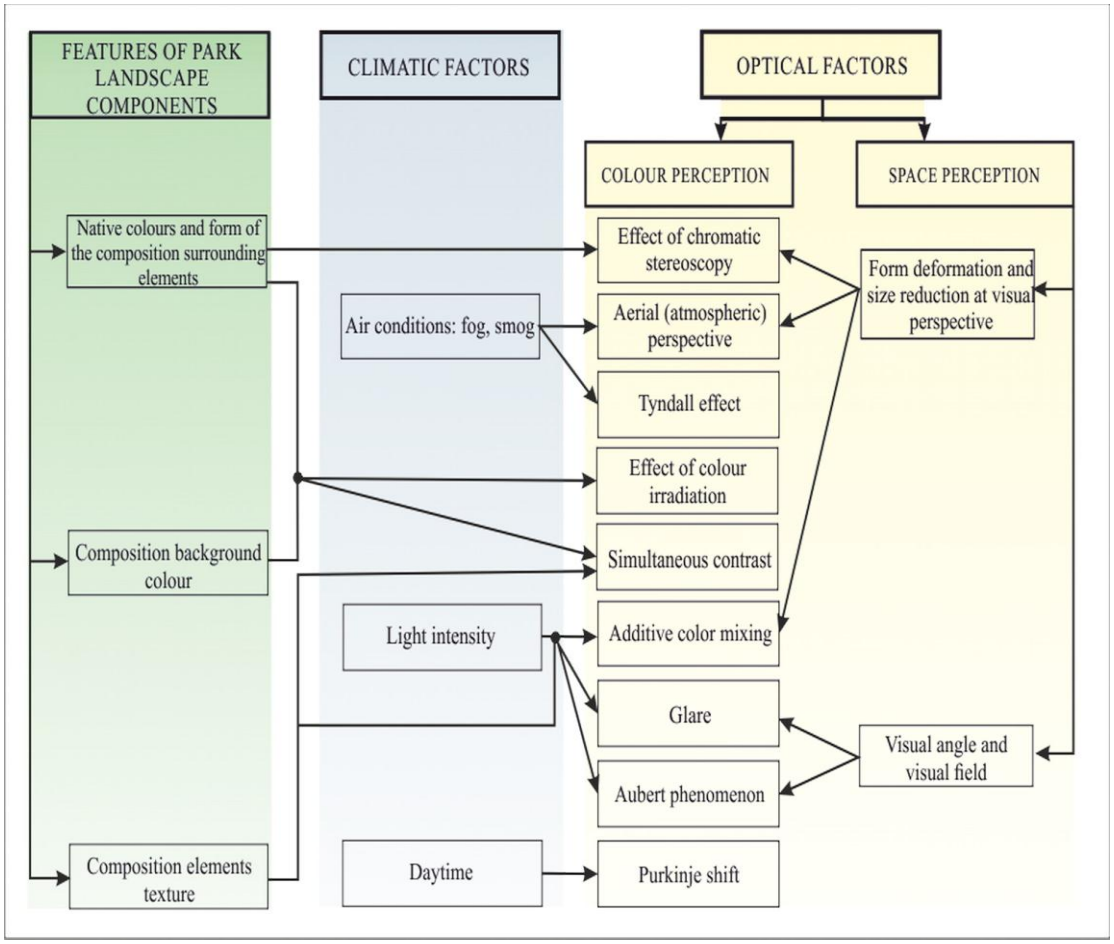

FIGURE 2 - SCHEME OF INTERCONNECTIONS OF OPTICAL PHENOMENA WITH FEATURES OF COLOUR-FORMING FACTORS

3.2. Climatic factors

As noted above, climatic factors act as a specific "filter" of perception, which has a significant impact on colour perception of landscape, it causes some optical phenomena, also affects directly on vegetation. As to the hierarchy of climatic factors, we have identified subgroups that have the impact on the creation and perception of landscape colouring and correlate as follows: the weather conditions depend on the region's climate, weather, in turn, determines the illumination at the moment of park landscape contemplation. They are presented in Figure 3.

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According to observation results on park landscape colouring variability of the research objects (Gatalska and Mavko, 2012; Oleksiichenko and Mavko, 2013), it is revealed that spring and summer colours are brighter and more saturated (since sunny days are dominating in this period). On the other hand autumn and winter park colouring (by cloudy weather) are characterized by less saturated colours. This pattern was observed in most parks (Figure 5).

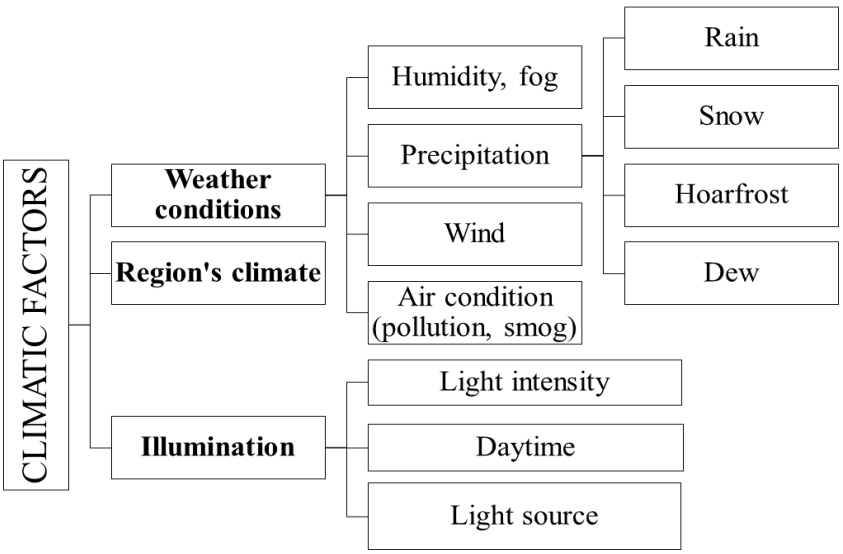


FIGURE 3 - STRUCTURE OF CLIMATIC FACTORS IN THE CONTEXT OF THEIR INFLUENCE ON LANDSCAPE COLOURING

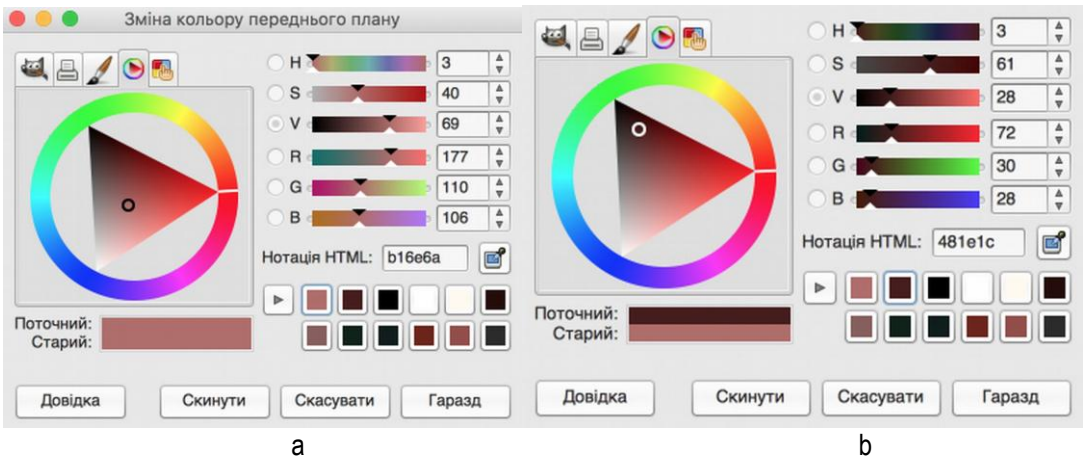
FIGURE 5 - CHANGES IN THE VIEWPOINT: A - SPRING (2.05.2013), SUNNY WEATHER, B - AUTUMN PHOTO (10.20.2014), AFTER RAIN

The colour of the sky is also determined by climatic factors, in particular region's climate depends on the number of sunny and gloomy days in the year, the appearance of the sky and clouds depends on weather conditions and illumination at the moment of observation. The sky creates a bright-blue, white or gloomy gray colour picture, depending on the daytime or season (Bos, 2008). The colour of blue sky changes daily, depending on the quantity of water drops in the air. The sky becomes white with an approximation of dispersion (areas of low atmospheric pressure) or in the summer when the air is dusty

(Minnaert, 1954). The sky is one of the most changeable and important colour bearer. For example, the sky occupies 25.9 % of the summer colouring of Feofania Park. Thus, the most of the sky is white (20.9%), and only 5.0% is light blue, because the sunlight is usually bright in summer.The weather conditions during the observation (presence of precipitation, fog, wind) also have a significant influence on the landscape architecture objects colouring. The presence of precipitation (rain, drizzle, snow, dew, hoarfrost) affects the colour of landscape, as follows: the colours become brighter due to humidity: a wet object, whatever colour it is, become in 2-3 times brighter than the dry object (Ruskin, *1860*). To study this pattern, observations on the KPI park were made in the same phenological phase both on the sunny day (July 11, 2017) and after the rain (July 13, 2017) (Figure 6). It is important to mention that Ruskin's (*1860*) pattern has been confirmed: the wet colour of the memorial doesn't change by hue, but it becomes darker (less degree of value) and more saturated (Figure 7).

a b

FIGURE 6 - PARK LANDSCAPE BEFORE AND AFTER RAIN: A - SUNNY DAY (JULY 11, 2017), B - CLOUDY, RAINY DAY (JULY 13, 2017)



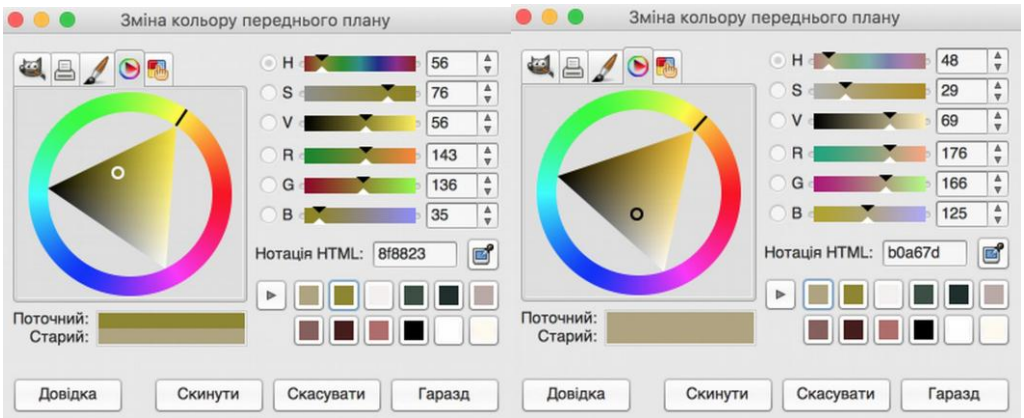
a b

FIGURE 7 - CHANGE OF HUE, SATURATION AND VALUE (HSV): A - DRY MONUMENT, B - WET MONUMENT

After rain, a special variety of landscapes are provided by glare: wet leaves in the crowns of trees scatter around light spots, but this luster can be observed only on the sunny side (Minnaert, 1954). We have observed the glares both after the rain and in bright illumination, so they add a white colour to the

park colouring. For example, in the Slavy Park, (Figure 6 b), they influence on the quantity of white colour in landscape colouring (Figure 9 b). The colours of objects that are viewed through the fog usually remain unchanged, the colour of the fog is also white, without bluish hue, the contrasts became less in the fog (Minnaert, 1954). According to Naumova (1992), the natural environment is characterized by "whitening" in the fog. This pattern is found in our study too (Figure 8). The hue of the Salix alba L. leaves (in the distance) was moved to the orange part of spectrum. It may be caused by the orange colours of surrounding greenery (the phenomenon of additive colour mixing), the saturation became less in the fog, and the colour becomes lighter (value increases — it becomes whiter).

a

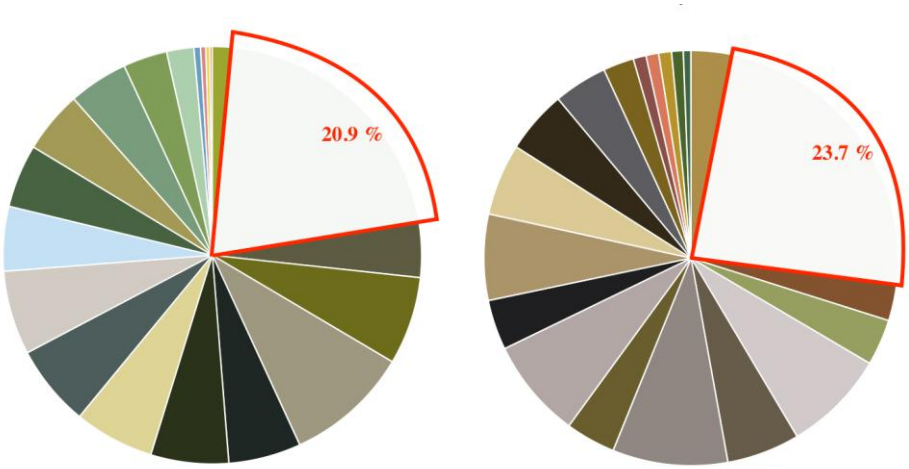


b c

FIGURE 8 - CHANGE OF PARK LANDSCAPE COLOUR IN THE FOG:a - PHOTOFIXATION OF THE VIEWPOINT (OCTOBER 27, 2016), b - HUE, SATURATION AND VALUE (HSV) OF THE COLOUR SALIX ALBA L. (IN A SHORT DISTANCE), c - HUE, SATURATION AND VALUE (HSV) OF THE COLOUR OF SALIX ALBA L. (IN A FAR DISTANCE, IN THE FOG).

Also, the variability of colour characteristics depends on the illumination, in particular: light sources, intensity of light and daytime (Figure 4). Illumination affects both the development of the landscape (as

a biological object) and the perception of its colours (Edensor, 2017). The perception of the same object will be different depending on which light source it is illuminated: solar or artificial lighting (Stepanov, 1985). Minnaert (1954) notes that the colour of brightly illuminated things goes to white, which is proved by our research too. Often, the sky, light-gray paving (especially in the summer) and glares become white. This pattern explains a significant percentage of white colour in park colouring, which in snowless periods reaches up to 20 % (Figure 9). The colour of all colour bearers varies by lightness under the influence of daylight.



a b

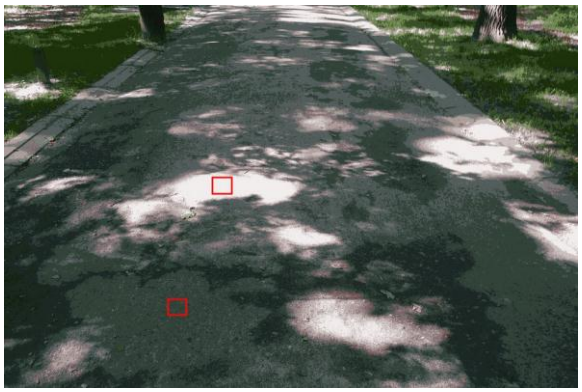
FIGURE 9 - A SEGMENT OF THE WHITE COLOUR IN PARK COLOURING (A - SUMMER, FEOFANIYA PARK, B - AUTUMN, SLAVY PARK)

Furthermore, sunlight causes a shadow. For example, in different illumination, the gray paving is changing from white (brightly illuminated areas) to dark gray (shaded areas), and also the blue colour of snow in the winter is caused by the shadows. The daytime also has influence on colours (Figure 10). The colours become softer in the evening (Minnaert, 1954).

a b c

FIGURE 10 - CHANGES IN LANDSCAPE COLOURING DURING THE DAY IN THE PAINTINGS BY CLAUDE MONET. VÉTHEUIL (1901): A - THE MORNING EFFECT, B - AFTERNOON, C - AT SUNSET ("CLAUDE MONET: ARTWORKS", 2018)

Today, we are continuing research in this direction. Although the intermediate results make it possible to notice the revealed changes in the hue of asphalt paving in different lighting conditions: illuminated fragments of the track became reddish hue, shaded became greenish (Figure 11). Perhaps this is due to the fact that the photo was taken in the morning (at 8:33), and according to Bohovaya-Kapper (1959), the eastern sun is coloured all in pinkish colours in the morning. The greenish hue of gray asphalt in the shadow is probably caused by the fact that the track is under the plantings cover, respectively, illuminated by scattered light that passed through the green leaves (colour reflection phenomenon).



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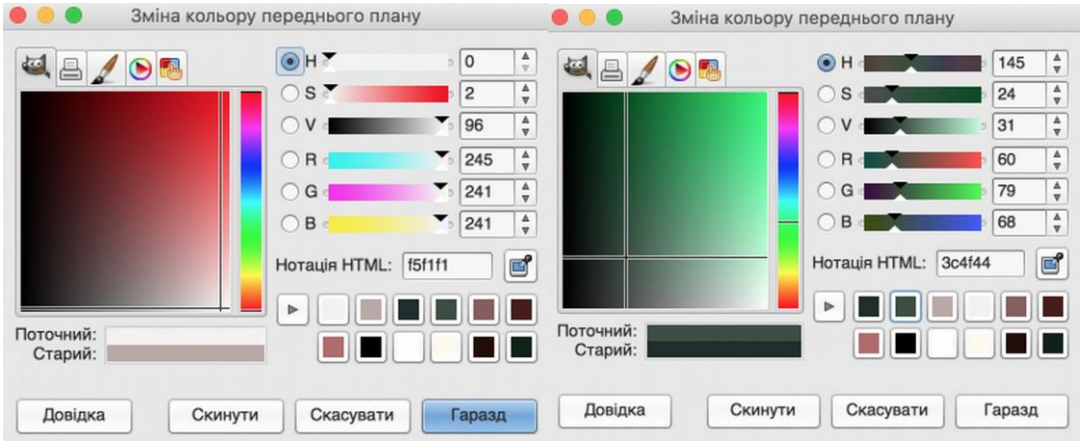

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FIGURE 11 - ASPHALT PAVING HUE CHANGE UNDER DIFFERENT LIGHTING CONDITIONS: a - INDEXED PHOTO, b - HUE OF BRIGHTLY ILLUMINATED PAVING, c - HUE OF SHADED PAVING

Regarding the daytime, the Purkinje shift is worth mentioining. Considering it, Pushkar (2007) offers flowerbeds of white and light yellow colour for evening parks. And when using colour outdoor lighting, the original colour of some park elements (in the evening) may be completely changed.

3.3. Park landscape components

The third group (see Figure 1) forms park colouring due to their own colours and includes the following park landscape components: greenery, relief, building, garden furniture, water, etc. (Figure 12).

Greenery is often the most important among the mentioned park landscape components. Seasonal dynamics is its main peculiarity. There are nine phases of park colour changing throughout the year (Bohovaya-Kapper, 1959). We recorded and analyzed park colour scheme during six periods, which were determined according to phenological phases by Schultz (1981). As per Kyiv parks colour seasonally analysis results, basic colours scheme that forms the colouring in different seasons was defined: winter - gray-blue colour scheme, the early spring - the gray-brown, culmination of the spring - brown-gray-green, full summer - white-gray-green, golden autumn - warm yellow-brown and gray colours, late autumn - brown-gray colour scheme.

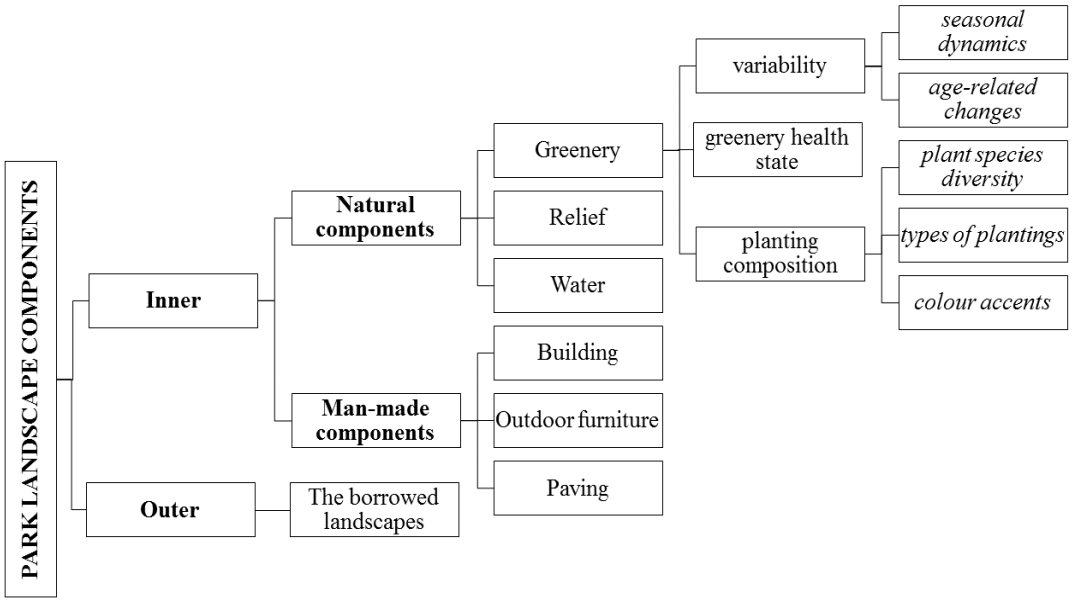

FIGURE 12 - THE STRUCTURE OF PARK LANDSCAPE COMPONENTS, THAT CREATE THE COLOURING

The analysis of the dominant colours in park landscapes reveals the relationship between the park colouring and plant species diversity. If the basis of the park greenery is deciduous woody trees and shrubs, they in fact determine the seasonal variability of landscape colouring. In this case, the most ornamental, in the coloristic aspect, will be the autumnal colouring that we observed in M. Rylsky Park in Holosiivo, where the brownish-yellow colours in the autumn period make up 45% in the overall park colouring (Figure 13). On the other hand, significant influence on the winter park colouring has a presence of evergreens. For example, in Peremoha Park (Figure 14), where part of gray-green colour of

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coniferous species (Pinus sylvestris L.) reaches 6.5% in the winter and in Feofania Park — up to 5.8%. There are a significant indicator compared to other parks (for example, there are no green plantings in winter colouring of M. Rylsky Park in Holosiivo). The health state of the plant directly influence on its colour, according to Breus & Oleksiichenko (2015), the neglect of some indicators of the seasonal development of beautiful flowering bushes caused to monotonous park landscape colouring during almost the entire growing season.

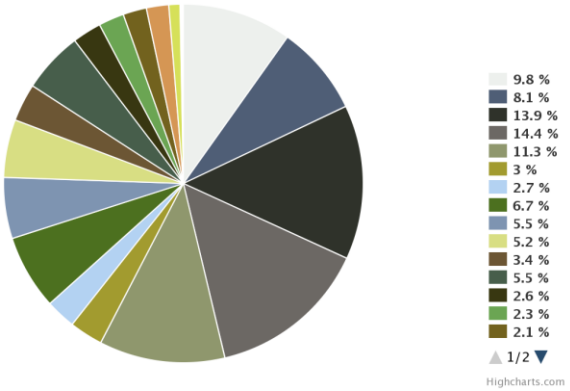


FIGURE 13 - AUTUMN COLOURING OF M. RYLSKY PARK IN HOLOSIIVO

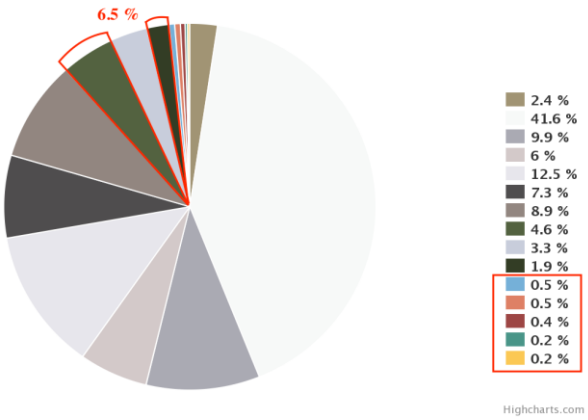


FIGURE 14 - WINTER COLOURING OF THE VICTORY PARK

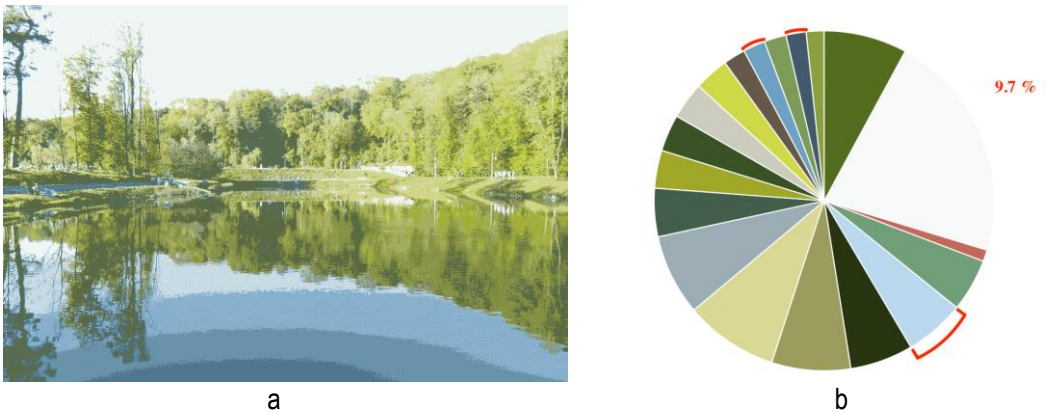
Colour accents (flowers, beautiful flowering bushes and trees, deciduous trees (in autumn), buildings, outdoor furniture etc.) are also important for park colouring formation. An example of accents used in Taras Shevchenko Park, where the persentage of colour accents varies from 4.6 to 10.0% at different seasons, and also in Peremoha Park - 1.8-5.7% (Figure 14). The variaety of park accents is presented in difererent colours: red (the autumn colours of Quercus rubra L., Rhus typhina L., Parthenocissus quinquefolia (L.) Planch.), purple (Prunus divaricata 'Atropurpurea', Berberis thunbergii 'Atropurpurea'), pink (blossom of Magnolia soulangeana Soul., Malus niedzwetzkyana Dieck.), yellow — blossom of Forsythia europaea Deg. et Bald., F. suspensa (Thunb.) Vahl., Kerria japonica (L.) DC., orange (in

autumn is represented by Acer platanoides L.) and multicolored flowerbeds, outdoor furniture at playgrounds. In addition, a problem with disharmonious coloration of outdoor furniture in relation to the surrounding park landscape was noted in all parks.

Except the outdoor furniture and constant colour bearers (paving, buildings), other components of park space has a great influence on park colouring as well (see Figure 12). The borrowed landscapes has a significant influence on the colouring of small urban parks. This is especially true during the winter season of the year. For example, in Taras Shevchenko Park the colours of borrowed landscapes in winter (in this case they are represented by buildings) occupy up to 10 %. Also, the borrowed landscapes are important in relief parks with panoramic views (for example, the Slavy Park).

The type of park space also determines the features of park landscape colouring, if the open spaces are dominating, the amount of large lawns will increase and park areas will be more lighted (Slavy Park). In case if the closed spaces are dominating - the brownish colour of tree trunks will occupy a significant percentage of colours on colouring scheme and there are a lot of shaded territories. In particular, in KPI Park, where plantings are represented by high trees, shrubs are almost absent, the coloration of tree trunks plays a very important role in the formation of park colouring and reach up to 20 %. So, the types of planting that are represented in the park also depend on its colouring.

Water in the park landscape makes a significant contribution to its colour diversity. The static ponds reflects surrounding landscapes. They also have their own blue colour, the presence and quantity of which depends on the weather (we observed brown, white (the ice), green water colours). A characteristic feature of the Feofaniya Park is the presence of a network of ponds, depending on the weather conditions and season the quantity of the blue water colour was 5.8-9.7% (Figure 14). Also, the blue colour of ponds is present in M. Rylsky Park in Holosiivo (4.6-9.2%).



a b

FIGURE 14 - POND IN THE COLOURING OF FEOFANIYA PARK: a - INDEXED PHOTO, b - COLOURS PERCENTAGE IN PARK LANDSCAPE (SPRING)

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4. CONCLUSIONS

The park landscape colouring is a dynamic phenomenon, which is formed by landscape components and is conditioned by the factors of human perception. According to the research results the hierarchical structure of colour-forming components and factors of landscape colour perceptions was formed and their interrelationships were revealed. The most changeable park landscape components are plants, the seasonal dynamics of which is a determining characteristic of park colouring. The optical and climatic factors can be considered as specific "filters", which influence the perception of park landscape colouring. They can not be changed, only taken into account by landscape architect.

The analysis of theoretical research papers about peculiarities of studying landscape colour theory and the research results of colour assessment of six Kyiv parks confirmed the influence of weather conditions on park landscape colouring (in particular, the patterns of colour changing of wet and brightly lighting objects, the effect of colours "whitening" in the fog).

The further research can be focused on the formation of a complex system of existing knowledge of colour theory, which is actual for landscape architecture objects, the identification of patterns of colour variability in the natural environment and the development of tools for the purposeful colour formation in the design of landscape objects, taking into account the seasonal dynamics of plants, as the main colour bearers of the park space and other colour-forming components and influence factors of landscape colouring perception.

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