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TREE SPECIES DIVERSITY IN THE SANITARY PROTECTION ZONE OF THE «BIOSPHERE CORPORATION» IN THE CITY OF DNIPRO, UKRAINE

Bessonova V. P., Dzhygan O. P.
Dnipro State Agrarian and Economic University
elenapriymak@ua.fm

This article analyzes species diversity in experimental plot which located on special health protection zones of industrial company inthe city of Dnipro. The aim of this research was to investigation the influence of anthropogenic emissions on plant distributing by their height, diameter of the bole and phytosanitary condition. The woody plantation requires reconstruction

Sanitary protection zone, plantation, species diversity, phytosanitary condition

During recent decades, the problem of contamination of the environment with antropogenic pollutants became more and more actual in modern megalopolises all over the world. Due to increase in output production the level of air pollution in

technogenically transformed areas with industrial emissions is constantly rising [2, 21, 22]. The city of Dnipro is one of the most heavily industrialized regional centers exposed to high anthropogenic loads attributable to the facilities of the metallurgical, machinebuilding, chemical and other branches of industries. In such conditions there is a high rate of emissions per unit of the urban area [16]. In consequence of industrial activity of factories considerable quantity of harmful substances was founded in atmosphere. Fluorides, chlorides, gaseous sulfur compounds and nitrogen oxides are the most dangerous emission components [19, 23].

Greenery has a significant role to offset negative influence of industrial estates or affect the environment [3,5]. Thus special health protection zones are established. They provide plots with the specific regime of using and the amount of which makes it possible to reduce negative influence to environment to levels which are accepted by international standards [11].

Each industrial company should be surrounded by health protection zones, which have been established according to the standards [18].

They decrease the level of atmospheric air pollution, noise levels, and ensure the comfort of the climate [7, 17]. Green plants in the territories of industrial sites and sanitary protection zones improve the esthetic view of the space and serve a decorative function [9]. To effectively implement the sanitary protection zone of these functions, sufficient diversity of the tree species of plantations and its ecological compliance with the conditions of growth, stability to the airport of a particular manufacturing plant is necessary.

Under the influence of components of industrial emissions, accelerated aging of individual systems of the plant organism occurs [8], which is accompanied by changes in the activity of enzymes, damage to cells and organs [24], which reduces the for environment [4, 6, 13, 14]. Periodic monitoring of the species composition and life status of the plantings of the sanitary protection zone of the sanitary protection plantings is necessary for the development of recommendations for the reconstruction of the plantings.

The purpose of the present study was to determine the species composition and the vital condition of the tree planting of the sanitary protection zone of «Biosphere Corporation».

Materials and Methods

The investigations have been carried out in woody planting of the sanitary protection zone of «Biosphere Corporation»which was located in the city of Dnipro. Total area of the health protection zones according to the standards is 5.35 ha. The site where the facilities of «Biosphere Corporation» are located, borders with Prydniprovsk Repair and Mechanical Plant which has a section ofopen-hearth plant and workshop assembly.

Prydniprovsk TES is located in the remote area, about 3 km away from the «Biosphere Corporation». The area of sanitary protection zone of the above-mentioned industrial facility has a length of 240 m from the north and 223 m from the east, width is about 250 m.

Throughout the area of the sanitary protection zone there are tree stands. The study area of the sanitary protection zone was nominally divided into two sites. The first one is directly adjacent to the buildings of the enterprise, the second one is located across the road.

On the first site trees were planted by single plantations at a distance of 4–5 m from each other.

In the rows of the Chinese poplar (17 spc.) which grows along the alley to the main entrance, large gaps between the trees (9–14 m) are noted due to the dead trees. Further in the alley there are ordinary plantings of horse-chestnut (13 spc.) – 100 m and large-leaved linden (25 spc.) – 100 m. At the end of the main avenue there is a gap (65 m) in front of the administrative entrance. Further – ordinary plantings of Chinese poplar – 78 m (15 spc.) and white poplar– 60 m (12 spc.).

The second site is a small forest area with a dense stand and a large number of poles. The main emissions of the plant are sulfuric anhydride (SO_2) and nitrogen oxides (NO and NO_2). These substances are spread by air and negatively affect the state of plants.

The research was carried out in accordance with generally accepted methods on the basis of research and requirements for

the registration of plantings. The inventory was carried out in accordance with the requirements of the «Instructions for the technical inventory of green plantations in cities and towns of the urban type of Ukraine» [15]. The species composition of the dendroflora was determined by backgrounders [10, 12]. The diameter of the trunk was determined in centimeters at a height of 1.3 m from the root neck with a fork (measurement accuracy ± 1 cm). The height was measured with the altimeter «Suunto». The degree of damage and damage to leaves on the scale is visually determined [20].

Results and discussion

In total, 1103 woody species were recorded in sanitary protection zone. Deciduous treewere dominants and comprised 56.21 % of all numbers of trees whereas coniferous plants were 43.79 % respectively. The species composition of trees included 11 family (*Betulaceae*, *Aceraceae*, *Bignoniaceae*, *Fabaceae*, *Fagaceae*, *Juglandaceae*, *Hippocastanaceae*, *Pinaceae*, *Salicaceae*, *Tiliaceae*, *Ulmaceae*) and 15 woody species european white birch (*Betula pendula* Roth.), white willow (*Salix alba* L.), Chinese elm (*Ulmus parvifolia* Rupp.), Persian walnut *(Juglans regia* L.), petiolate oak (*Quercus robur* L.), smoking bean (*Catalpa bignonioides* Walter.), Norway maple (*Acer platanoides* L.), horse chestnut (*Aesculus hippocastanum* L.), large-leaved linden (*Tilia platyphyllos* Scop.), black locust (*Robinia pseudoacacia* L.), blackpine (*Pinus nigra* ssp. Pallasiana), white poplar *(Populus alba* Torr.), Chinese poplar (*Populus simonii* Carriere), black poplar (*Populus nigra* L.), white spruce (*Picea glauca* (Engelm) (Tab. 1).

We found out that large number of species belong to the familySalicaceae (four species) and to the family Pinaceae (two species). It must be noted that another families are representated only by one species.

According to the data obtained, it was reasonable to rank the families in following order of decreasing of specimens number: *Pinaceae* > *Salicaceae* > *Betulaceae* > *Fagaceae* > *Tiliaceae* > *Hippocastanaceae* > *Fabaceae* > *Aceraceae* > *Juglandaceae* > *Ulmaceae* = *Bignoniaceae*. Our data suggest that *Pinus nigra*

ssp. Pallasiana is represented by the largest number of specimens (476 spc.) and was 43.15 % of the total specimens number.

Table 1 – Species composition of planting in a sanitaryprotection zone of the «Biosphere Corporation»

Species	Total number, spc.	% of the total specimens number	Nat./in.
1	2	3	4
Division *Gymnospermae*			
Family *Pinaceae*			
Pinus nigra ssp. Pallasiana	476	43.15	in.
Picea glauca (Engelm)	7	0.64	in.
Division *Magnoliophyta*			
Family *Betulaceae* Gray.			
Betula pendula Roth.	40	3.63	nat.
Family *Bignoniaceae* Juss.			
Catalpa bignonioides Walter	1	0.09	in.
Family *Fabaceae* Lindl.			
Robinia pseudoacacia L.	19	1.72	in.
Family *Fagaceae* A.B.R.			
Quercus robur L.	30	2.72	nat.
Family *Salicacea* Lindl.			
Salix alba L.	15	1.36	nat.
Populus alba Torr.	291	26.38	in.
Populus nigra L.	50	4.53	nat.
Populus simonii Carriere	94	8.52	in.
Family *Ulmaceae* Mirb.			
Ulmus parvifolia Rupp.	1	0.09	in.
Family *Hippocastanaceae* Torr.et Grey			
Aesculus hippocastanum L.	20	1.81	in.

Continuation of Table

1	2	3	4
Family *Juglandaceae* Lindl.			
Juglans regia L.	7	0.64	in.
Family *Aceraceae* Lindl.			
Acer platanoides L.	27	2.45	nat.
Family *Tiliaceae* Juss.			
Tilia platyphyllos Scop.	25	2.27	nat.
Total:	1103	100	

Note: in. – introduced species, nat. – native species

Second highest in terms of quantity was *Populus alba* which comprised 26.38 % (291 spc.) of the total numberof specimens. *Populus simonii* was quite widespread species in the study area and the amount of trees equals 8.52 % (94 spc.). The amount of other species is less than fifty pieces. In the sanitary protection zone only five species were native – *Betula pendula*, *Acer platanoides*, *Quercus robur*, *Populus nigra*, *Salix alba*. Their amount was 14.68 % of the total amount of trees. The number of introduced species (*Pinus nigra* ssp. Pallasiana, *Aesculus hippocastanum*, *Juglans regia*, *Ulmus parvifolia*, *Tilia platyphyllos*, *Robinia pseudoacacia*, *Populus alba*, *Populus simonii*, *Picea glauca*) was 85.31 % the total amount of trees.

We investigated distribution of plants by their height and found out that the highest number of specimens was 42.17 % (275 spc.) (category of trees 4–5.9 m). Species of this category were ranked in decreasing order of the number of specimens: *Pinus nigra* (148 spc. – 53.81 %), *Populus alba* (84 spc. – 30.54 %), *Tilia platyphyllos* (17 spc. – 6.18 %), *Salix alba* (8 spc. – 2.90 %), *Populus simonii* (8 spc.– 2.90 %), *Populus nigra* (4 spc. – 1.48 %), *Aesculus hippocastanum* (3 spc. – 1.11 %), *Picea glauca* (1 spc. – 0.37 %) (Fig. 1).

Our results show that the least number of specimens was made up 0.31 % (2 spc.) (category of trees 18–19.9 m). Only one speciesin this category has been found (*Pinus nigra*). The highest

trees in sanitary protection zone were *Pinus nigra* in category20–21.9 m (3 spc.).

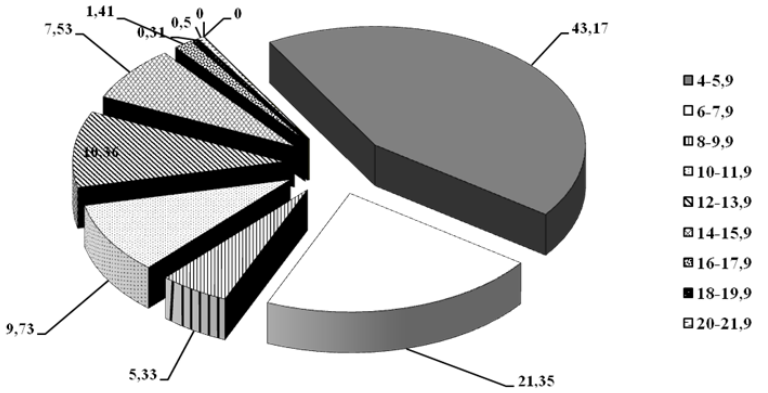

Figure 1 – Distribution of trees by their height in a sanitary protection zone of the «Biosphere Corporation», %

The analysis of plants by the diameter of the bole indicated that the largest group were trees of category from 6 cm to 9.9 cm (Tab.2). Their number was 35.95 % of the total amount of trees and equaled 229 spc. This category was represented by *Pinus nigra* (140 spc. – 61.13 %), *Populus alba* (64spc. – 27.94 %), *Populus simonii* (3 spc.– 1.31 %), *Populus nigra* (6 spc. – 2.62 %), *Picea glauca* (4 spc.– 1.74 %). According to the data obtained the least number of specimens were in category from 70 cm to73.9 cm (2 spc. of *Populus alba*) and in category from 78 cm to 81.9 cm (1 spc. of *Populus alba* and 1 spc. of *Salix alba*).

It is known that tree condition and current quality are important indicators of viability of green plantings. All woody plants were studied in accordance with the scale of phytosanitary conditions [20]. The health conditions of trees assessed the situation are the following: 0 points were given to trees without damage and perfectly healthy, 1 point was given to moderately damage plants, 2 points were given to the trees with medium damage, 3 points were given to badly weakened plants, 4 points

were given to severely defoliated plants, 5 points were given to dead-wood of this year's and 6 points were given to dead-wood of previous years. Our data suggest that 130 specimens of *Pinus nigra* were in category with 0 points; it comprised 20.75 % of the total amount of trees on sites and 50.78 % of the numbers of this specimen (Tab. 3).

Pinus nigra is tolerant to stress climate and soil conditions. Our results show that pine needless of trees were intense green and annual increment was normal. However, others trees of this species which belonged to another group of vitality conditions were damaged by stem wood diseases, pests (carpet beetles) and high level of stem damage.

We registered ooze of gum due to damage of the bark. Vitality category I includes 203 specimens of trees (31.86 %). Among these species more than 40.0 % represent *Salix alba, Robinia pseudoacacia, Populus alba, Populus simonii, Picea glauca*. Category II is composed of 164 trees (25.74 %), III – 91 spc. (14.28 %), IV – 39 spc. (6.12 %), V – 9 spc. (1.42 %), VI – 3 spc. (0.47 %). We found out that all members of these species are affected by pests. Our data suggest that brown spot, black spot and white spot damaged *Populus alba, Acer platanoides* and *Populus alba* respectively. *Tilia platyphyllos* was affected by linden gall midge. The worst condition is of *Aesculus hippocastanum* due to significant percentage of leaves tissue damaged by the horse-chestnut leaf miner. Apart from the diseases and pests the phytosanitary condition has been influenced by such factors as withered branches (341 trees), dry top of a tree, damaged by frost, hollow and defective trees. More withered branches had *Pinus nigra* and *Populus alba*. The dry top of the tree observed in 131 trees. These species were *Betula pendula, Salix alba, Robinia pseudoacacia, Populus alba* and *Populus simonii*. The most affected was *Populus simonii* (90 spc. and 68.70 % of all trees in this category). Hollows had only two species: *Betula pendula* (1 specimens) and *Populus nigra* (2 specimens).

Thus, according to calculations by the formula [1], the planting in sanitary protection zone had are moderately weakened.

Table 2 – Distribution of woody plants in a sanitary protection zone of the «Biosphere Corporation» by the diameter of the bole

Species	Diameter, cm									
	2–9.9	10–17.9	18–25.9	26–33.9	34–41.9	42–49.9	50–57.9	58–65.9	66–73.9	74–81.9
Betula pendula	–	2/28.57	–	2/28.57	3/42.86	–	–	–	–	–
Salix alba	8/61.54	–	1/7.69	2/15.39	–	–	1/7.69	–	–	1/7.69
Aesculus hippocastanum	–	19/95.00	–	1/5.00	–	–	–	–	–	–
Acer platanoides	2/18.18	2/18.18	4/36.36	3/27.27	–	–	–	–	–	–
Tilia platyphyllos	2/8.00	17/68.00	6/24.00	–	–	–	–	–	–	–
Robinia pseudoacacia	–	5/33.33	3/19.99	1/6.66	6/39.99	–	–	–	–	–
Pinus nigra	156/60.94	63/24.60	12/4.68	15/5.86	3/1.17	–	1/0.39	6/2.34	–	–
Populus alba	83/48.53	27/15.79	11/5.94	12/6.53	13/7.59	11/5.46	6/2.05	2/0.68	5/1.72	1/0.34
Populus simonii	11/11.70	4/4.26	4/4.26	–	1/5.55	19/20.22	10/10.63	4/4.25	–	–
Populus nigra	7/38.88	6/33.33	2/11.11	–	1/5.55	1/5.55	1/5.55	–	–	–
Picea glauca	4/57.15	3/42.85	–	–	–	–	–	–	–	–
Total, (spc., %):	273/42.86	146/22.91	43/6.75	56/8.79	48/7.53	31/4.86	19/2.98	16/2.51	5/0.78	2/0.31

Note: numerator – number of trees, spc., denomirator – % of the total amount of specimens

Table 3 – Distribution of woody plants by phytosanitary condition

Species	Category of conditions (point)							Total amount
	0	I	II	III	IV	V	VI	
Betula pendula	–	3/42.86	–	2/28.57	2/28.57	–	1/42.86	7/100
Salix alba	–	11/92.32	1/7.69	–	1/7.69	–	–	13/100
Aesculus hippocastanum	–	–	–	13/65.00	4/20.00	3/15.00	–	20/100
Acer platanoides	–	7/60.00	1/10.00	3/30.00	–	–	–	11/100
Tilia platyphyllos	–	–	23/92.00	1/4.00	1/4.00	–	–	25/100
Robinia pseudoacacia	–	3/20.00	1/6.67	9/20.00	2/13.33	–	–	15/100
Pinusnigra	135/50.78	53/20.70	45/17.57	14/5.46	9/3.51	3/1.71	–	256/100
Populus alba	–	71/40.93	80/46.78	10/5.84	7/4.09	3/1.57	2/0.78	171/100
Populus simonii	–	25/45.74	18/6.40	32/34.04	13/13.82	–	–	94/100
Populus nigra	–	3/16.66	8/44.44	7/38.88	–	–	–	18/100
Picea glauca	–	7/100	–	–	–	–	–	7/100
Total:	135/21.19	183/28.73	177/27.79	91/14.28	39/6.12	9/1.42	3/0.47	637/100

Note: numerator – number of trees, spc., denomirator – % of the total amount of specimens

Conclusions:

Our research shows that:

1. The species composition of plantation in sanitary protection zone of the «Biosphere Corporation» in the city of Dnipro includes 15 species in quantity of 637 specimens among which 56.21 % were deciduous trees and 9 introduced species (85.31 % of all numbers of plants). Especially great amout is represented by the family Pinaceae (483 spc.) and the least amount belongs to the families *Bignoniaceae* and *Juglandaceae*.

2. It was found out that the main diameter of the trees bole ranged from 2 cm to 9 cm and main plant height ranged from 4 m to 6.0 m. The largest group of the trees by diameter of the bole included plants category from 6 cm to 9.9 cm (42.86 % of the total specimens). Thus, 43 % of planting had height from 4 m to 5.9 m and only 3 specimens had height of 21 m.

3. The prevailing amount of tress in sanitary protection zone were moderately weakened (28.73 % of all numbers of specimens). These group included more than a half of the specimens *Salix alba* and *Acer platanoides*. Trees without damage and perfectly healthy included 21.19 %, badly weakened plant included 14.28 % and dead-wood of last year included 1.89 % from total amount of plants.

4. The design of green plantations of the sanitary protection zone of the «Biosphere corporation» is satisfactory, but it needed reconstruction in order to increase the environmental cleaning role.

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РІЗНОМАНІТТЯ ДЕНДРОФЛОРИ САНІТАРНО-ЗАХИСНОЇ ЗОНИ ПІДПРИЄМСТВА «БІОСФЕРА» У м. ДНІПРО, УКРАЇНА

Бессонова В. П., Джиган О. П.
Дніпровський державний аграрно-економічний університет
elenapriymak@ua.fm

Досліджено видовий склад та життєвий стан зелених насаджень у санітарно-захисній зоні підприємства «Біосфера» м. Дніпро. Загальна площа санітарно-захисної зони складала 5,35 га. Досліджувана територія була умовно розділена на дві ділянки. Перша безпосередньо прилягала до забудов підприємства, друга – розташована через автомобільну дорогу. На ділянці 1 дерева висаджені рядовими посадками на відстані 4–5 м одне від одного. Ділянка 2 являє собою невеликий лісовий масив. Насадження щільні, відмічається велика кількість підросту. Головними викидами даного підприємства є сірчаний ангідрид та оксиди азоту. Облік насаджень проводили за загальноприйнятими методиками.

У санітарно-захисні зоні зростає 1103 екземпляри деревних порід. З них хвойних 483 шт. (43,79 %), листяних – 620 шт. (56,21 %). Видовий склад представлений 11-ма родинами та 15-ма видами. Найбільша кількість видів належить до родини *Salicacea* (26,7 % від загальної кількості видів). Встановлено, що найбільшу кількість екземплярів за розподілом рослин за висотою має категорія 4–5,9 м – 275 шт. (42,17 %). Найменшу кількість має категорія 18–19,9 м, що складає 0,31 % від загальної кількості дерев, і представлена лише одним видом – *Pinus nigra*.

Виявлено, що найчисленнішою є група рослин, діаметр штамбу яких коливається від 6 до 9,9 см. Їх число дорівнює 229 шт., що становить 35,95 % від загального числа.

Найменшою кількістю представлені дерева зі значеннями цього показника від 74 до 81,9 см (0,31 %).

Встановлено, що переважна кількість дерев санітарно-захисної зони є помірно ослабленими – 28,73 % щодо усіх екземплярів. Понад п'ятдесят відсотків таких дерев належать до видів *Salix alba* та *Acer platanoides*. Рослини без ознак ослаблення складають 21,19 % від їх загальної кількості, сильно ослаблених – 14,28 %. До сухостою належать 1,89 % дерев.

Конструкція зелених насаджень санітарно-захисної зони корпорації «Біосфера» потребує реконструкції з метою підвищення їх середоочищаючої функції.