FACULTY OF CIVIL AND
ENVIRONMENTAL ENGINEERING
BIAŁYSTOK UNIVERSITY
OF TECHNOLOGY

POLISH ASSOCIATION
OF SANITARY ENGINEERS
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„ENVIRONMENTAL ENGINEERING – THROUGH A YOUNG EYE”

VOLUME 29

ENVIRONMENTAL ENGINEERING SYSTEMS

Edited by
Iwona Skoczko
Janina Piekutin
Magdalena Horysz
Łukasz Malinowski

Białystok 2016

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Polskie Zrzeszenie Techników i Inżynierów Sanitarnych Oddział w Białymstoku
ul. M. C. Skłodowskiej 2, 15-950 Białystok
Tel.: 85 744 31 00
e-mail: konferencjapzits@gmail.cm
www.pzits.bialystok.pl

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M. Sc. Robert Piotr Cabaj[1)]
University of Warmia and Mazury in Olsztyn
Department of Entomology, Phytopathology and Molecular Diagnostics
ul. Michała Oczapowskiego 2, 10-719 Olsztyn
[1)] r.p.cabaj@gmail.com

Significance of grassland ecosystems in protecting selected components of the natural environment

Key words: *grassland, soil, air, environment, protection*

Summary: Even without its valuable production function as a source of feed for farmed animals, grassland is crucially important to the natural environment. Existing literature highlights the protective role that meadows and pastures play with respect to several components of the natural environment. Due to the specific microclimate they generate, such ecosystems are capable of containing solid and gas air pollutants, while the specific root system of these plants allows them to prevent soil erosion. Additionally, grassland is conducive to producing an increased volume of soil organic matter and grass vegetation has been found to reduce the leaching of nutrients delivered through fertilisation. Analysed body of research demonstrates that grassland may serve as an effective buffer zone around water bodies, thus limiting water contamination by pollutants generated through excessive fertilisation.

1. Introduction

Meadows and pastures are inextricable from agricultural production. This is due to their widely recognised production function, making them a valuable source of cheap feed for the livestock. Areas that are chiefly designated for grassland include those with highly moisturised soils and uneven surface, features that often make them unusable for growing other crops [1]. The share of meadows and pastures in agricultural land in Poland accounts only for a little over 20%. However, the recent and ongoing development of the idea of sustainable agriculture in the country has emphasised the significance of these areas' non-production functions as well. From the vantage point of broadly defined environmental protection, permanent pastures have an important protective role to play in several components of the natural environment [2,3]. the most crucial of them being air purification, prevention of soil erosion and protection of surface waters. This allows for the contention that grassland ecosystems have a positive impact on several specific components of the natural environment [4]. which is supported by a seizable body of research. Analysing the non-production functions of grasslands one cannot disregard their considerable significance in the context of preserving biodiversity, which is attributed primarily to the species diversity of plants making up meadow sward [8]. Moreover, the specific character of ecosystems based on permanent pastures makes them an appropriate habitat for an array of animal species [3,4]. The present agricultural management systems in Poland and other European countries are paying increasing attention to the need for preserving biodiversity. To this end, the European Community has established the Rural Development Programme in Poland, whose primary aim is to provide financial support for initiatives fostering the competitiveness of the Polish agricultural sector. A substantial proportion of the funds is also spent on a range of measures aimed at protecting the natural environment and limiting the adverse effects it suffers on account of agricultural production [5]. Under the pro-environmental management system, which is garnering growing support in Poland, increasing attention is given to the non-production value of grassland ecosystems. It is worthy of mention that many landscape architects and artists believe permanent pastures to be an integral and significant element of a developing agricultural landscape [6,7,8].

This work presents a review of extant research on the crucial part that permanent pastures play in the protection of three key components of the natural environment: soil, air and surface water.

2. Permanent pasture and soil protection

As an important element of the environment, soil is exposed to a major threat of erosion. Largely influenced by the climatic conditions of a given country or region, these processes are divided into wind erosion, surface water erosion and gully erosion.[9] Nearly 30% of arable land and wooded areas in Poland are exposed to some kind of erosion. The pie chart given in Figure 1 shows that 27.9% of land is exposed to surface water erosion, 18.2% to gully erosion, and 28.2% to wind erosion [10].

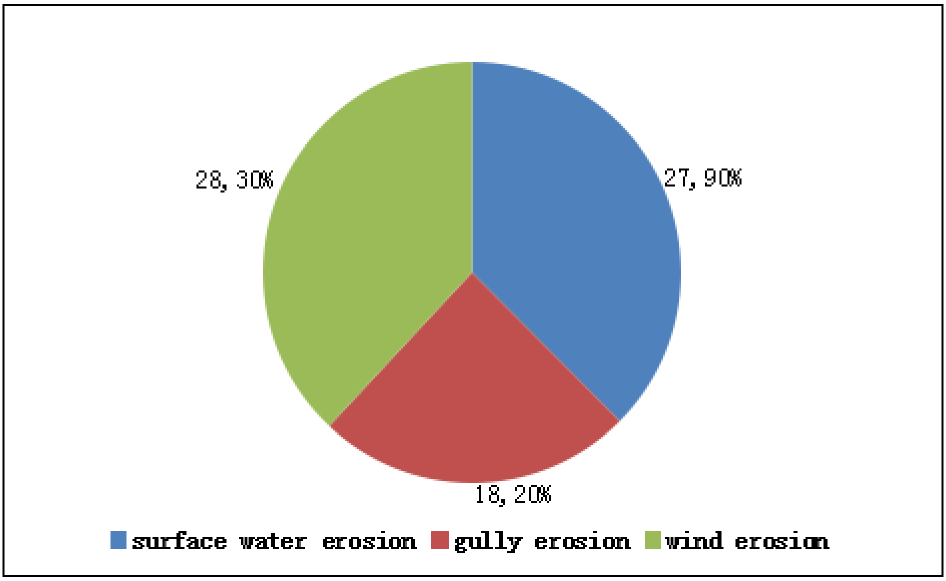


Figure 1. Exposure of arable land and wooded areas to erosion

Source: Own elaboration based on Ochrona środowiska 1998

These data show soil erosion to be a serious problem in the country that needs to be tackled. One of the measures that can be taken to limit the process of soil erosion is to sod the surface of land exposed to it. Admittedly, the quickest and cheapest method of sodding is sowing grass vegetation, which creates very dense sward serving as a protective layer over the surface of the soil. Soil erosion has become a global problem. However, although it is a natural process that takes several thousand years to complete, it is often reinforced by human activity, leading to inadequate spatial management. It is widely recognised that the primary causes of the global problem of soil erosion include excessive removal of vegetation, inadequate animal grazing and implementing agricultural economy [11].

A study was carried out in the USA into erosion rainwash of dusty soil, demonstrating set-aside land to be 122 times more vulnerable to water erosion than land covered with turf [12]. A significant advantage of meadow plants and an argument for growing them on eroded areas is their remarkable adaptability to harsh soil and climatic conditions [13]. Grassland's positive contribution to limiting erosion processes has already been recognised in the north-eastern area of the country known as the Green Lungs of Poland, where sodding with grass plants was used for managing local moraine hills. This has led to rising the overall share of meadows and pastures in land structure, contributing to the area's agricultural production based on meadow and pasture economy as well as bovine, dairy cattle and sheep production. A large proportion of grassland in total land structure not only prevents soil erosion but also, combined with a high rate of afforestation, positively enhances the environmental value of the region, thus also boosting its tourist attractiveness [14].

A distinct semantic group worth mentioning here is peat soils, which are formed where decayed organic matter is deposited under anaerobic conditions that hinder the process of mineralisation. Various sorts of peat are produced in the marshy environment, which is characterised by high levels of moisture. Three types of mires can be distinguished depending on the type of water that accompanies their formation. These are: fens, raised bogs and transition mires [15].

The formation of fens involves nutrient-rich surface water and groundwater moving horizontally, and they are characteristically located in low lying areas within river valleys, although they may also form as a result of a lake drying out. Fens are dominated by grass-like plants belonging to the *Phragmitetea* class and sedge-moss fen vegetation in the class *Scheuchzerio-Caricetea nigrae.* They are also home to numerous grass and herb species of the class *Molinio-Arrhenatheretea* as well as rushes and woody plants of the class *Alnetea glutionosae* [14,15].

Four groups of fen are identified based on the plant species that compose the peat: moss fens, sedge fens, reed fens and alder fens. Moss fen is used to denote an area with a predominance of low sedge and a concentration of rusty peat moss [18]. while sedge fens are dominated by tall sedges, reed and other tall-growing hydrophilic plants. Further, reed fens denote plant concentrations with a clear prevalence of reed, whereas alder fens are mainly populated by woody plants with a dominance of alder woods [15].

Characterised by high acidity, raised bogs are fuelled by water derived from precipitation and have little capacity to hold nutrients in the deposit profile. They are chiefly formed on watersheds and are populated by numerous flowering plants, including *Carex limosa* and *Drosera* as well as vegetation belonging to the classes *Vaccinio-Piceata* and *Oxycocco-Sphagnetea* [16].

The final type of mires is transitional mire. As the name itself indicates, it represents a transitional form between fens and raised bogs, as all the three types of water contribute to their formation. The transitional character of these mires pertains to both their fertility as well as the plants they are home to [14,15,16].

Peat soils account for nearly 5% of land in Poland, with an overwhelming majority of them (90%) being classified as fens. As is shown in Figure 2, just above 70% of total mire area is dedicated to permanent pastures, whereas mires existing in their natural state account for less than 10% in this breakdown [17].

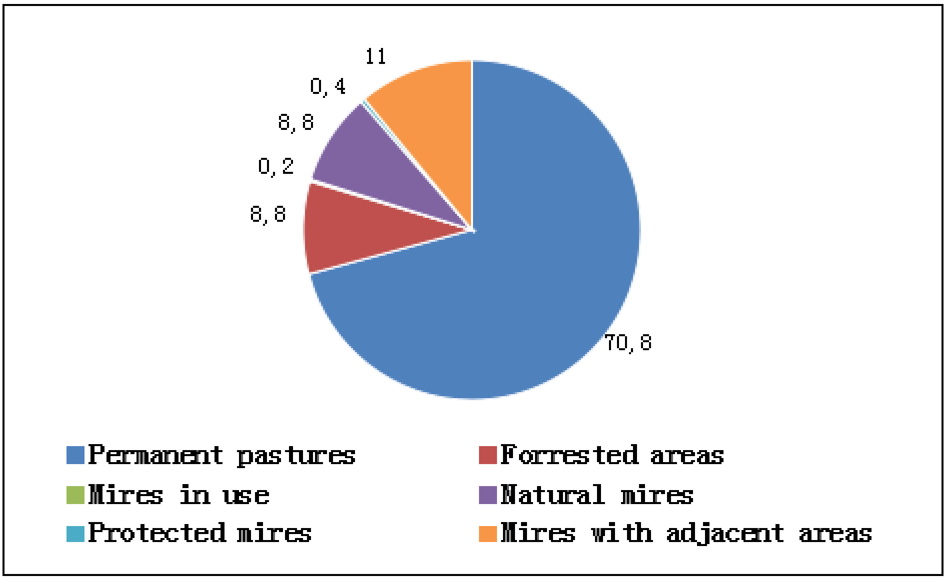


Figure 2. Mire area in Poland, broken down by land use

Source: Own elaboration based on Gajda 1989

The wide variation in how mire areas are used and the fact that a scant 0.4% of them are now protected call for taking measures to preserve peat soils. Their specific character stems from high nitrogen and organic matter content, which makes them require adequate agricultural economy.

These areas are fit for agricultural production only after a prior land reclamation, which in turn is conducive to boosting the process of mineralisation, decreasing the amount of organic matter and consequently lowering the level of the mire. Such treatment is also related to a gradual dying out of the multiple vegetation species inhabiting the mire [16,17]. According to a study by Gotkiewicz (1991), the surface of mire areas dedicated to grassland fell by 1.3 cm annually, while the same decrease in field use was 1.6 cm. It is worth mentioning that a drop by one centimetre in mire surface amounts to a total annual loss of 15.3 t of organic dry matter nationally [18]. Peat soils with their characteristically high level of moisture make for favourable development conditions for meadow vegetation, the presence of which contributes substantially to lowering the rate of organic matter mineralisation. It is, therefore, justified to argue that the optimal way of utilising appropriately-reclaimed peat land is to dedicate it to be used as permanent pasture [17,18].

Yet another useful role that grassland plays in protecting the soil is reducing nutrient leaching. The intensification of agricultural production entails delivering higher doses of nutrients to ensure the proper development of crop plants. The downside of this process is that the plants only partially use the micro- and macroelements delivered, with the remainder posing a threat to groundwater and unenclosed waters. This holds especially true for nitrogen and phosphorus residues [19]. In his research, Kopeć (1985) showed that using fertiliser doses at 80 kg/ha for phosphorus and 120 kg/ha for potassium allowed meadow plants to effectively use nitrogen from fertiliser delivered to a permanent pasture located on brown soil with a pH value of 7. This finding indicates that using moderate mineral fertilisation on meadows and pastures poses no threat to both open waters and groundwater [20].

Having their roots infected by rhizobia, the Fabaceae contribute to the process of fixing nitrogen, which is then converted into nitrate forms that are more accessible to plants. Thus, having the meadow sward composed by the Fabaceae allows for reducing the amount of nitrogen delivered through mineral fertilisation, which is of crucial environmental importance. Moreover, permanent pastures as separate ecosystems play a key role in the process of nitrogen fixation, thus increasing the value of grassland in the broadly defined protection of the environment [21].

Odum (1971) emphasises the significance of grassland in producing soil organic matter, which is a determining factor in soil fertility, and hails permanent pasture as being the most efficient primary-production ecosystem in the world [22]. It should be kept in mind, however, that grassland ecosystems have their volume of primary production largely determined by habitat conditions, in particular climatic conditions and species composition of the meadow sward [21,22].

3. The role of meadows and pastures in air and water purification

The capacity of grass vegetation to contain air pollutants in both solid and gas state stems from the specific microclimate that is produced in such ecosystems, characterised by high air humidity and increased presence of dew. Air pollutants settle on the surface of grass vegetation in response to a decreased air flow during contact with the rough and uneven surface of these plants. Then, as a result of evapotranspiration taking place on the surface of grass, a process of water vapour condensation is triggered by dust. The vapour subsequently settles on plant surface, leading to the flattening out of the temperature amplitude. As a result, the air becomes more humid and pure, with its lower layer under the height of 2 m becoming free from bacteria and viruses [23]. As Rutkowska and Pawluśkiewicz (1996) observe, grassland is indirectly responsible for lowering air temperature on hot days by up to 6 ^{o} C. This is made possible by the intensive evaporation at the surface of grass vegetation, which leads to enhanced air humidity at ground level. The role grass plays in air purification and its capacity to increase the amount of oxygen account for why lawns are gaining a growing presence in the urban setting [24].

At a time of unfavourable changes taking place in the aquatic environment, some common examples being the lowering level of water in all sorts of water bodies and the rising level of agriculture-produced pollution, proper preservation of surface water and groundwater has become a key priority for water management in agriculture. For these reasons, areas adjacent to water courses as well as natural and artificial water bodies should be designated to form a sort of buffer zones [25,26,27]. The findings of Leopold and Blińska (1992) show phosphorous run-off from permanent pasture to be over three times lower compared with arable land. Grassland in the form of extensive meadows and pastures may serve as a cost-efficient buffer zone, provided that its width is adjusted to existing soil conditions and the lie of the land [28].

4. Conclusions

Analysis of existing literature gives grounds for the following conclusions:

1. Due to their specific root system, grass vegetation contributes significantly to limiting the processes of wind and water erosion.

2. When present in land use structure, permanent pasture is conducive to producing an increased volume of soil organic matter.
3. Due to the specific microclimate it generates, grassland plays an air-filtering role by containing air pollutants.
4. The surface of permanent pasture substantially limits water contamination by pollutants generated by the use of chemicals in agriculture.
5. Grass ecosystems ought to be uniformly distributed across the urban and agricultural landscape alike. This will allow full exploitation of grass vegetation and its capacity to protect some of the key components of the natural environment.

References:

1. Moraczewski R.: *Łąki i pastwiska w gospodarstwie rolnym* [Meadows and pastures on the agricultural farm]. Fundacja rozwoju SGGW, Warszawa, 1996.
2. Grzegorczyk S.: *Użytki zielone w rolniczej przestrzeni produkcyjnej Polski na tle państw Unii Europejskiej* [Grassland in the Polish agricultural production space against the background of EU member states]. Zeszyty Problemowe Postępu Nauk Rolniczych, Vol. 549, 2010.
3. Stypiński P., Grzegorczyk S.: *Gospodarcze i środowiskowe funkcje użytków zielonych we współczesnym rolnictwie* [Economic and environmental functions of grassland in modern agriculture]. Bibliotheca Fragmenta Agronomica, Vol. 9, 2005.
4. Rogalski M.: *Łąkarstwo* [Grassland science]. Kurpisz, Poznań, 2004.

5. Alberski J.: *Programy rolno środowiskowe a ochrona walorów przyrodniczych i wydajność użytków zielonych siedlisk nizinnych. Użytki zielone w gospodarstwach ekologicznych* [Agri-environmental programmes and preserving natural value and productivity of grassland in lowland habitats: Grassland on the ecological farm]. Wyd. UWM, Olsztyn, 2013.
6. Jończyk K., Stalenga J.: *Możliwości rozwoju różnych systemów gospodarowania w Polsce* [Development prospects for different agricultural management systems in Poland]. In: Możliwości rozwoju gospodarstw o różnych kierunkach produkcji rolniczej w Polsce [Development prospects for farms with different profiles of agricultural production]. Studia i Raporty IUNG-PIB, Z22, 2010.
7. Jaszczak A.: *Ochrona przyrodniczych i kulturowych wartości krajobrazu rolniczego. Krajobraz kształtowany przez kulturę rolną* [Preserving the environmental and cultural value of agricultural landscape: The agriculture-shaped landscape]. Wyd. UWM, Olsztyn, 2006.
8. Marks M., Młynarczyk K., Marks E.: *Użytki zielone w różnych systemach rolniczych* [Grassland in different agricultural systems]. *Pamiętnik Puławski*, Vol. 125, 2001.
9. Turski R. A., Słowińska-Jurkiewicz A., Hetman J.: *Zarys gleboznawstwa* [Overview of Soil Science]. Wydawnictwo Akademii Rolniczej w Lublinie, Lublin, 1999.
10. Data on environmental protection provided by the Central Statistical Office. Warszawa, 1998.
11. Zawadzki S.: *Gleboznawstwo* [Soil Science]. Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa, 1999.

12. Myczkowski S.: *Człowiek – przyroda- cywilizacja* [Man – Nature – Civilisation]. PWN, Warszawa, 1976.
13. Bałuch A., Benedycki S.: *Wpływ mieszanek motylkowato-trawiastych i nawożenia mineralnego na żyzność gleby* [Impact of papilionaceous-grass mixtures and mineral fertilisation on soil fertility], *Annales UMCS, Sec. E,* 59, 1. Lublin 2004, page 441–448.
14. Grzegorczyk S., Benedycki S.: *Łąkoznawstwo* [Grassland science]. Wyd. UWM, Olsztyn, 2001.
15. Pawluczuk J., Gotkiewicz J.: *Ocena procesu mineralizacji azotu w glebach wybranych ekosystemów torfowiskowych Polski północno-wschodniej w aspekcie ochrony zasobów glebowych* [Assessing nitrogen mineralisation in soils of selected mire ecosystems of north-eastern Poland in the context of preserving soil resources]. Acta Agrophysica *1*(4), 2003.
16. Pawluczuk J., Grabowski K.: *Zbiorowiska łąkowe na glebach murszowych w dolinie rzeki Omulew* [Meadow assemblages on muck soils in the Omulew River valley]. Łąkarstwo w Polsce, Vol. 15, 2012.
17. Gajda J.: *Użytkowanie torfowisk w Polsce w porównaniu z innymi krajami: Materiały konferencyjne nauk technicznych* [Using mire areas in Poland compared with other countries: Technical sciences conference materials], Aktualne problemy światowego torfoznawstwa w świetle VIII Międzynarodowego Kongresu Torfowego [Current issues in global peat science in light of the 8th International Peat Congress], Białystok, 1989.
18. Gotkiewicz J., Gotkiewicz M.: *Gospodarowanie azotem na glebach torfowych* [Nitrogen management on peat soils]. Biblioteczka IMUZ, Falenty, 1991.

19. Tkaczyk P., Chwil S.: *Formy i frakcje fosforu mineralnego w glebie nawożonej nawozami mineralnymi i obornikiem* [Forms and fractions of mineral phosphorus in the soil receiving mineral fertilisation and manure], Annales UMCS, Sec. E, Vol. LIX (4), 2004, page. 1723–1730.
20. Kopeć S.: *Wpływ nawożenia mineralnego użytków zielonych na wypłukiwanie składników pokarmowych z gleby*. *Materiały sympozjum* [Impact of mineral fertilisation of grassland on the leaching of nutrients from the soil. Symposium materials]. Ochrona Środowiska a intensyfikacja produkcji zwierzęcej [Environmental protection and intensification of livestock production]. Wyd. Instytutu Zootechniki, Kraków, 1985.
21. Bałuch-Małecka A., Olszewska M.: *Wpływ składu gatunkowego mieszanek i nawożenia mineralnego na produkcyjność przemiennych użytków zielonych w warunkach Pojezierza Olsztyńskiego* [Impact of mixture species composition and mineral fertilisation on the productivity of temporary pastures under the Olszyt Lake District conditions], Łąkarstwo w Polsce, Vol. 11. 2008, page 9–16.
22. Odum E. P.: *Fundamentals of Ecology*. W.B. Sanders Co., Philadelphia, 1971.
23. Kotowski W.: *Wartości przyrodnicze fitocenoz siedlisk rolniczych w dolinach rzecznych. Woda-Środowisko-Obszary Wiejskie* [Natural value of phytocenoses in river-valley agricultural habitats: Water – Environment – Rural Areas], Rozprawy naukowe i monografie 4, 2002.
24. Rutkowska B., Pawluśkiewicz M.: *Trawniki* [Lawns]. Państwowe wydawnictwo Rolnicze i Leśne, Warszawa, 1996.

25. Falkowski M., Kukułka I., Kozłowski S.: *Łąka jako bariera ekologiczna migracji składników mineralnych do wód* [The meadow as an ecological barrier to nutrient migration to water]. Roczniki Akademii Rolniczej, Vol. 284, 1996.
26. Jankowska-Huflejt H.: *Rola trwałych użytków zielonych w obiegu wód i ochronie ich zasobów* [Role of permanent pastures in water circulation and preserving water resources]. In: *Woda na obszarach wiejskich* [Water in rural areas]. Wydawnictwo IMUZ. Ministry of Agriculture and Rural Development. Warszawa, Falenty, 2009.
27. Smoroń S.: *Obieg fosforu w rolnictwie i zagrożenie jakości wody* [Phosphorus circulation in agriculture and a threat to water quality], *Zeszyty Edukacyjne 1*. Wyd. IMUZ, Falenty, 1996, page 87–104.
28. Leopold M., Blińska M.: *Gospodarka rybacka a ekorozwój* [Fisheries economy and ecological development]. Zeszyty problemowe Postępu Nauk Rolniczych, 1992.

MSc Eng. Katarzyna Dereń[1)], Prof. Assoc. Antoni Szewczyk,
PhD Beata Cieniawska, MSc Eng. Tomasz Klimza
Wrocław University of Environmental and Life Sciences
Faculty of Natural Sciences and Technology
Agricultural Engineering
ul. C. K. Norwida 27, 50-375 Wrocław
[1)]katarzynaderen@up.wroc.pl

The degree of coverage on the intended objects in the characterizing spraying plants

Keywords: *spray deposit, covering degree, coefficient surface sprayed plants, sprayer, spraying*

Summary: The aim of the study was to determine the surface coverage of sprayed plants depending on the coefficient of the spray surface. The study was conducted at the Institute of Agricultural Engineering of the University of Life Sciences in the laboratory. Sprayers during the experiment moved at a constant operating speed. The study selected two nozzles of one stream of liquid (standard and ejector). The objects studied were water sensitive papers, which were placed on vertical and horizontal surfaces artificial plants. The degree of coverage was determined using computerized image analysis method.

It was found that the coefficient surface of the spray has an impact on the degree of coverage on the intended size of the plant. Characteristics of spray plants facilitates the selection of the right kind of atomizer spray to perform the surgery - which reduces the consumption of plant protection products and reduce the environmental pollution and water pollution chemical harmful substances.

1. Introduction

Through the use of chemical plant protection, it is possible to obtain a high crop of quality and quantity, and reduce the cost of crop production [1, 2]. You have to remember that pesticides used in plant protection products are substances that are harmful to the environment and living organisms. Plant protection products (PPP) because of the great varieties and availability are often the cause of many diseases, poisoning and sometimes death. [3]. Excess used plant protection chemicals is accumulated in the soil, and then penetrates into the groundwater and the water reservoirs. The reason for this occurrence may be the wrong choice of plant protection or poorly executed surgery spraying [4].

A very important task of today's plant protection technology is to reduce the use of plant protection products. To do this ensures adequate quality of the treatment plant protection. The quality of a spraying is affected by many factors. One of them is to choose a spray nozzle for surgery. Should pay attention to type, size and operating parameters (pressure, working height, spacing on the boom, setting) nozzle. Then you can perform the correct procedure to protect plants and achieve a high degree of coverage and application of liquid sprayed on plants [5, 6, 7, 8;9, 10, 11, 12].

Biological efficacy plant protection chemicals depends on the type and dose of preparation used, the amount of spray liquid per hectare, the development phase of the crop and plants competitive, and the date of the procedure [13,14,15,16]. Another important factor is the weather: temperature, relative air humidity, wind speed and direction [17].

Indicators defining the quality of the treatment are: coverage of sprayed objects, spray deposit and distribution of fall liquid spray [18, 19, 20, 21]. None of the methods of determining quality indicators surgery protection does not include the characteristics of the sprayed object, which determines the coefficient surface spray W_{po}. According to the authors, this factor will help increase the efficiency of spraying, while limiting the risk to the environment [22, 23, 24].

The aim of the study was to determine the degree of surface coverage of sprayed plants, depending on the ratio of the spray surface at a constant speed drive of the sprayer for selected types of nozzles.

2. Material and methods

The research was conducted in the laboratory at the Institute of Agricultural Engineering at the University of Life Sciences in Wroclaw. Selected for the two air induction nozzles of the same intensity liquid discharge:

- GAT 110-02 TWIN AIR GUARDIAN (fig.1.a) a two-stream Company HYPRO (liquid streams with 30 ° deviation - one forward and one backward (fig.1.b)),
- FC-GA 110-02 GUARDIAN AIRTM (fig.2.a) a one-stream CompanyHYPRO (stream with a deviation of 10-15 ° (fig.2.b)).

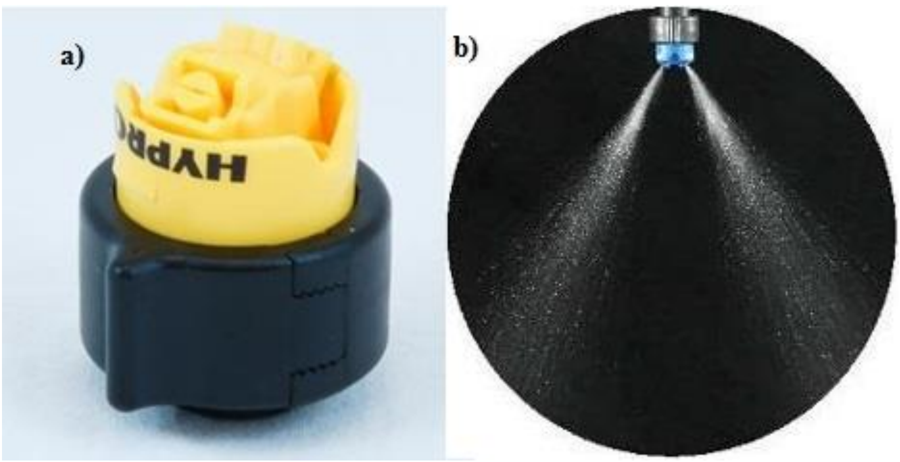


Figure 1 a) GAT 110-02 GUARDIAN AIR TWIN, b) the two streams of aerated with a slope of 30 ° to the front and backward

Source: Own study based on [25,26]

Figure 2. a) FC-GA 110-02 GUARDIAN AIRTM, b) flat stream with a deviation of 10-15 °

Source: Own study based on [27,28]

The research degree of coverage was carried out using self-propelled sprayer [17, 8, 29], as schematically shown in fig. 3. Sprayer move to the preset speed after a strictly defined section, which consisted of three parts (fig 3).

Adopted are spraying parameters:

- constant speed of 8 $km \cdot h^{-1}$,
- liquid pressure of 0.2 and 0.4 MPa (spray rate amounted to 97.5 $l \cdot ha^{-1}$ and 137 $l \cdot ha^{-1}$)
- height of the nozzles of 0.5 m.

At the measuring section (10 meter) set at three meters three artificial plants, which are further repetitions. Examined a sample in the form of papers water sensitive, which were placed on vertical surfaces: transverse approach (A_{nj}), transverse leaving (A_{oj}), longitudinal left (A_{pl}) longitudinal right (A_{pp}) and horizontal surfaces (upper level (A_{pg}) and the lower level (A_{pd})) artificial plants fig .4.

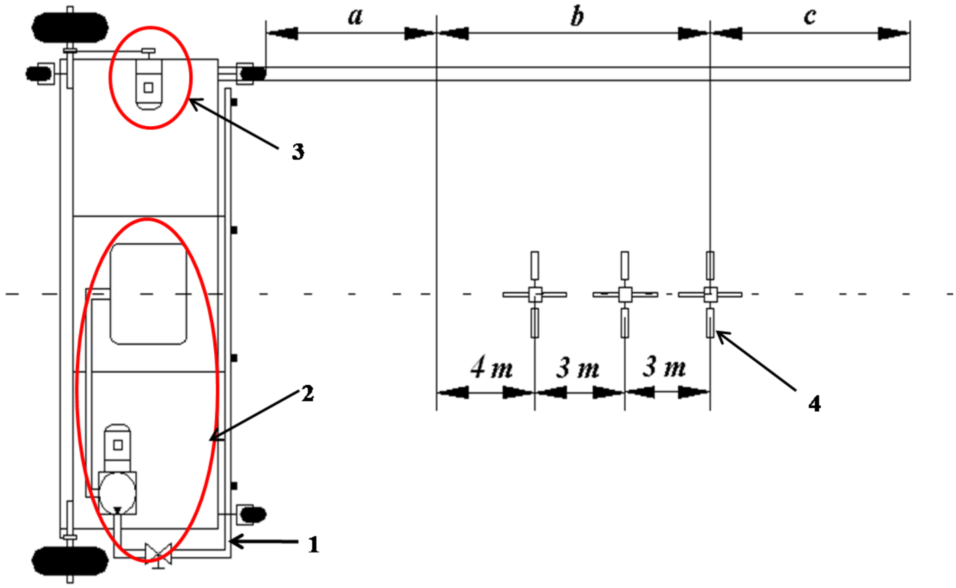


Figure 3. Schematic representation of the measurement stand: a – run line, b – a measurement line, c – ending line, 1 – sprayers carrier, 2 – nozzles, 3 – drive system, 4 – an artificial plant

Source: Own study

The degree of coverage determined using a computer image analysis (Adobe Photoshop 7.0). In the area of water sensitive paper randomly chosen three fragments of an area of 10x10mm, and read percent of sprayed surface. Then, using the formula 1 calculated the degree of coverage:

$$\boldsymbol{P_{sp} = \frac{W_k}{W_p} \cdot 100\%} \tag{1}$$

where:

$\boldsymbol{P_{sp}}$– degree of coverage [%],

$\boldsymbol{W_K}$ – surface covered with liquid [pixels],

$\boldsymbol{W_p}$ – area of 1 cm^2 [pixels].

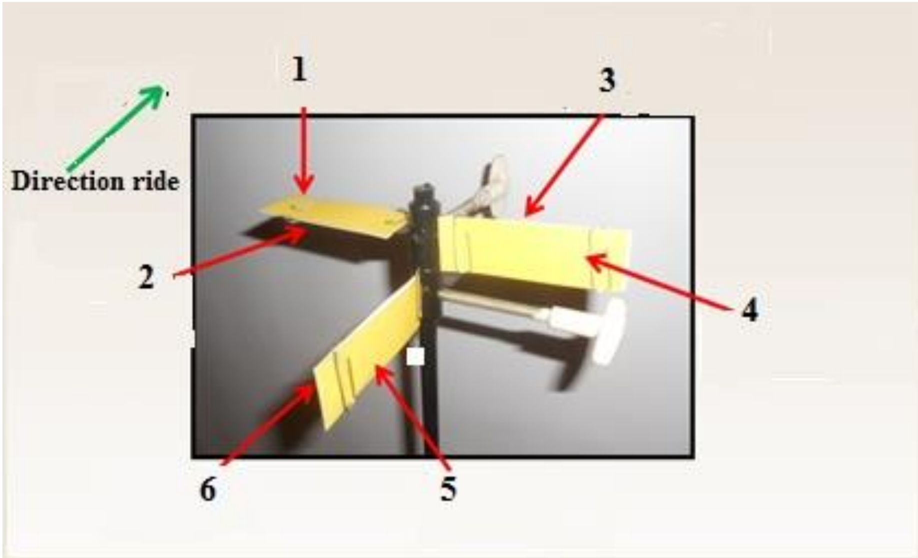


Figure 4. View of an artificial plant with marked researched facilities: 1 – upper level (A_{pg}), 2 – lower level (A_{pd}), 3 – vertical transverse leaving (A_{oj}), 4 – vertical transverse approach (A_{nj}), 5 – vertical longitudinal right (A_{pp}), 6 – vertical longitudinal left (A_{pl})
Source: Own study

Water sensitive paper has been attached to the artificial plants in such a way that you can determine the coefficient of surface spray from the relationship:

$$\boldsymbol{W_{po}} = \frac{\boldsymbol{projection\ vertical\ surface}}{\boldsymbol{projection\ horizontal\ surface}} \qquad (2)$$

where:
$\boldsymbol{W_{po}}$ – coefficient of surface spray [-].

Adopted are coefficients W_{po}: 0,25; 0,50; 0,75; 1; 1,25; 1,50; 1,75; 2. Studies using artificial plants allow the adoption coefficient of any surface spray W_{po}. This was done by the configuration of the leaf orientation, to obtain a plant coefficient required for a constant surface area (Table 1).

Table 1. The total surface of the the horizontal and vertical projections for the different coefficients of surface spray.

No	Coefficient of surface spray W_{po}	Horizontal surfaces (a) [cm^2]		Vertical surfaces (b) [cm^2]			
				transverse		longitudinal	
		upper level	lower level	vertical approac h	vertical leaving	right	left
1	0,25	40	40	5	5	5	5
2	0,50	33,33	33,33	8,33	8,33	8,33	8,33
3	0,75	28,57	28,57	10,71	10,71	10,71	10,71
4	1,00	25	25	12,5	12,5	12,5	12,5
5	1,25	22,22	22,22	13,89	13,89	13,89	13,89
6	1,50	20	20	15	15	15	15
7	1,75	18,18	18,18	15,91	15,91	15,91	15,91
8	2,00	16,66	16,66	16,67	16,67	16,67	16,67

Source: Own study

3. Results and discussion

The results of the research coverage of sprayed objects for the test nozzles are shown in Figures 5-6. Graphs show the degree of coverage for the following surface samplers: upper level (A_{pg}), vertical transverse leaving (A_{oj}), vertical transverse approach (A_{nj}), vertical longitudinal right (A_{pp}), and vertical longitudinal left (A_{pl}). The analysis of the results omitted data sampler horizontal lower level (A_{pd}) because the method used to measure the degree of coverage showed no traces of drops on the lower level surface of the sampler.

The analysis of the graphs presented in Figures 5-6 show that the sprayer FCGA 110-02 is characterized by a greater degree of coverage (P_{sp}) of all surfaces sprayed with the exception of vertical transverse approach surfaces. The liquid pressure, which made the spraying, had no significant effect on the degree of surface coverage. For two the tested pressure nozzle GAT 110-02 better cover vertical transverse approach (A_{nj}). Similar studies confirmed Łuczycka and in.2014 and Szewczyk et al. 2012 in its publications, which stated that sprays a one-stream better, cover the sprayed surface than the two-stream nozzles [30, 8].

Air induction spray a one-stream FCGA 110-02 (pressure of 0.2 MPa) covers about 8% better upper level surface (A_{pg}) than a two-stream (GAT 110-02) sprayer. The smallest degree of coverage was observed for sprayer GAT 110-02 for covering vertical transverse leaving (A_{oj}) for a pressure of 0.2 and 0.4 MPa. It was observed that the degree of surface coverage of vertical longitudinal right (A_{pp}) at a pressure of 0.4 MPa for spray FCGA 110-02 is 5.2% higher than for spray GAT 110-02.

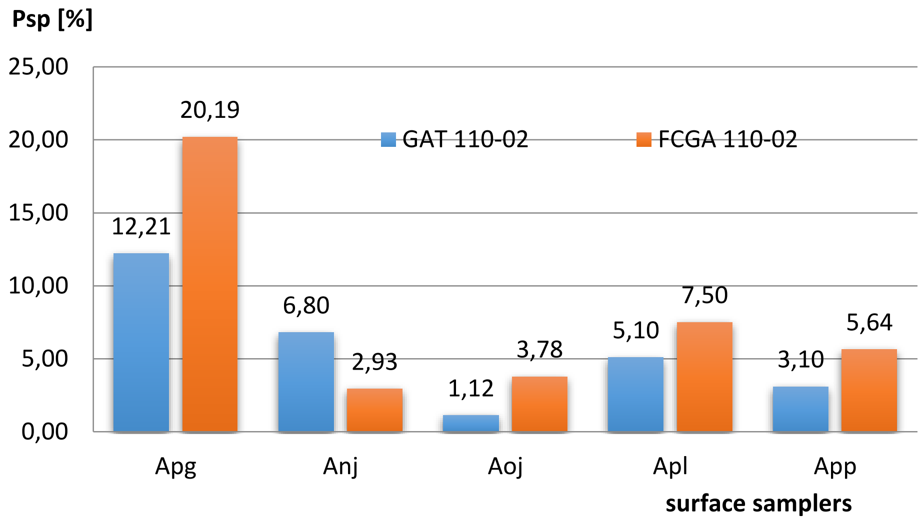


Figure 5. The degree of coverage (Psp) sprayed surface for a pressure of 0.2 MPa for the test nozzles

Source: Own study

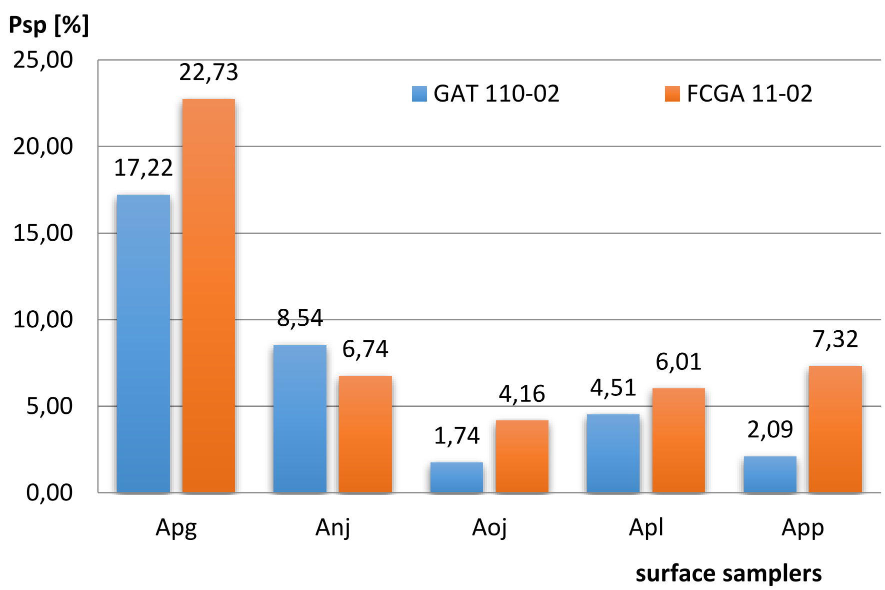


Figure 6. The degree of coverage (Psp) sprayed surface for a pressure of 0.4 MPa for the test nozzles

Source: Own study

The highest coverage was achieved for the upper horizontal samplers (A_{pg}) using spray one-stream FCGA 110-02 and amounted to 20.19%, for the pressure 0,2MPa, and 22.73% for the pressure of 0.4 MPa. The lowest coverage was recorded for samplers vertical transverse leaving (AOJ) using a sprayer with two streams GAT 110-02 and amounted to 1.12% for pressure 0,2MPa, and 1.74% for pressure 0,4MPa.

The graphs 7-8 shows the complete coverage (P_s) sprayed samplers depending on the coefficient of spraying the surface (W_{po}), and liquid pressure for nozzles types examined.

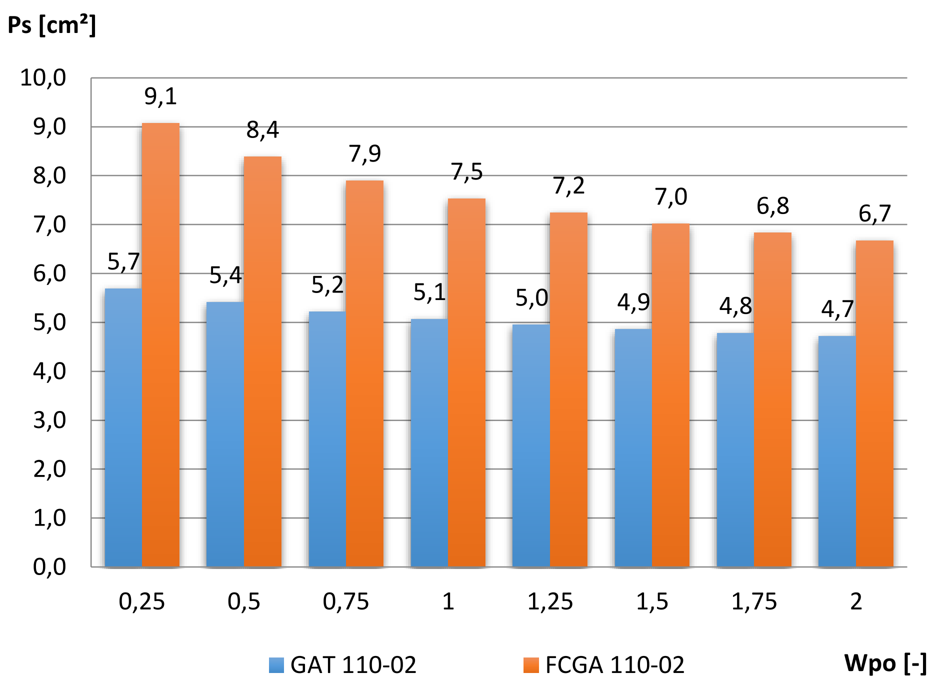


Figure 7. The aggregate coverage sprayed probes depending on the Wpo at a pressure of 0.2 MPa with the selected nozzles

Source: Own study

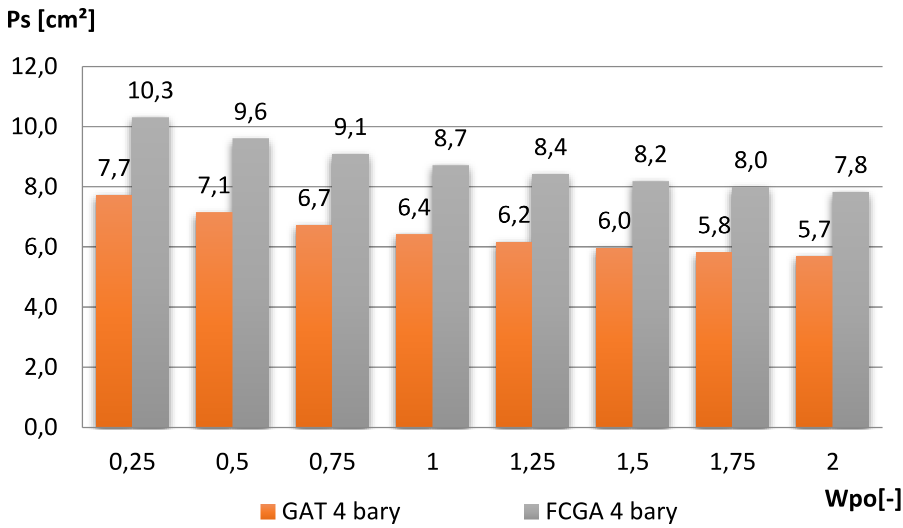


Figure 8. The aggregate coverage sprayed probes depending on the Wpo at a pressure of 0.4 MPa with the selected nozzles

Source: Own study

One-stream nozzles better cover the test surfaces for plants with a coefficient of surface spray less than unity (W_{po} <1, the plant has more horizontal surfaces) When the plants have more vertical surfaces (W_{po}> 1) of spray nozzles may be used one or two stream.

In figure 7-8 shows that the nozzle FCGA 110-02 has a higher variability of coverage independent of pressure. After changing the coefficient of the surface of the spray from the value W_{po}=2 to the value of W_{po}= 0.25, there was an increase in complete of coverage with a value of 6,7 to 9,1 cm^2, which is a 35% increase in coverage (for spray two-stream FCGA 110-02). For test nozzle, the pressure with which performed the study had no significant impact on the complete coverage surface (Fig. 7 and 8). This is a clear example of the need to analyze the possibility of nozzles in terms of their ability to cover the sprayed objects. Interpretation of the results is consistent with studies conducted so far, in which the authors say that it is important select the appropriate nozzle to perform spraying plants [5, 6, 7, 8, 9, 10, 11, 12]. The coefficient of surface spray will make it possible to increase the efficiency of spraying, while limiting the risk to the environment by reducing the use of plant protection products. This allows you to get high quality and effectiveness of the treatment [22, 23, 24].

4. Conclusion

1. Analysis of the results of research degree of coverage by using selected nozzles showed the existence of large differences in coverage of vertical and horizontal surfaces.
2. One-stream air induction nozzles (FC-GA 110-02) better cover sprayed on the surface irrespective of the for pressure with which the treatment was performed.
3. Two-stream air induction nozzle (GAT 110-02) better cover vertical transverse approach surfaces (A_{nj}).
4. When W_{po} <1 it is preferable to use spray nozzles a two-stream, and when W_{po}> 1 can be used sprayers one- and two-stream. Studies have shown how useful it is when choosing a nozzle coefficient of surface spray W_{po}.

References:

1. Walesiuk A., Wojewódzka-Żelazniakowicz M., Halim N., Łukasik-Głęboska M., Czaban S., Myćko G., Pazio L., Ładny J.: *Zatrucia środkami ochrony roślin,* Postępy Nauk Medycznych, nr 9, 2010, page 729-735.

2. Golinowska M.: *Ekonomika ochrony roślin w teorii i praktyce,* Progress in Plant Protection / Postępy w Ochronie Roślin, nr 49 (1), 2009, page 23-33.
3. Makles Z., Domański W.: *Ślady pestycydów – niebezpieczne dla człowieka i środowiska*, Bezpieczeństwo Pracy, nr 1, 2008, page 5.
4. Hołownicki R., Doruchowski G.: *Strefy ochronne o zróżnicowanej szerokości są konieczne*, [in:] *Racjonalna Technika Ochrony Roślin*, Materiały Konferencyjne, 2006, page 90-100.
5. Hołownicki R., Doruchowski G., Świechowski W., Jaeken P.: *Methods of evaluation of spray deposit and coverage on artificial targets,* Electronic Journal of Polish Agriculture Universities, nr 5(1), 2002, page 1-9.
6. Lipiński A., Choszcz D., Konopka S.: *Ocena rozpylaczy do oprysku ziemniaków w aspekcie równomierności pokrycia roślin cieczą,* Inżynieria Rolnicza, nr 9(97), 2007, page 135-141.
7. Godyń A., Hołownicki R., Doruchowski G., Świechowski W.: *Ocena rozkładu cieczy opryskowej w sadzie jabłoniowym wykonana za pomocą papieru wodnoczułego*. Inżynieria Rolnicza, nr 102 (4), 2008, page 299-306.
8. Szewczyk A., Łuczycka D., Cieniawska B., Rojek G.: *Porównanie stopnia pokrycia obiektów opryskiwanych wybranymi rozpylaczami eżektorowymi – jedno i dwustrumieniowym*, Inżynieria Rolnicza, nr 2(136), 2012, page 325-334.
9. Godyń A.: *Nowości w rozpylaczach do herbicydów*, Warzywa, nr 8, 2009, page 61-63.
10. Kierzek R.: *Skuteczna ochrona roślin [cz. II]. Dobór rozpylaczy do zabiegów polowych*, Ochrona Roślin, nr 1 (52), 2007, page 32-35.

11. Kierzek R.: *Wiele rozpylaczy, jeden oprysk*, Top Agrar, nr 7–8, 2008, page 118–121.
12. Tadel E.: *Technika ochrony polowych upraw wysokich ze szczególnym uwzględnieniem kukurydzy*, [in:] *Racjonalna Technika Ochrony Roślin*, Materiały Konferencyjne, 2007, page 100-106.
13. Krawczyk R.: *Aspekty stosowania obniżonych dawek herbicydów w zbożach jarych*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 46 (1), 2006, page 223-231.
14. Krawczyk R.: *Wpływ terminu stosowania zredukowanych dawek herbicydów w zbożach jarych na efektywność zwalczania chwastów*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 47 (3), 2007, page 151-158.
15. Krawczyk R.: *Obniżona dawka herbicydu – uwarunkowania, badania i praktyka*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 48 (2), 2008, page 621-627.
16. Matysiak K.: *Ocena stosowania obniżonych dawek wybranych herbicydów z grupy sulfonylomoczników w pszenicy jarej i jęczmieniu jarym*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 48 (3), 2008, page 1150-1155.
17. Szewczyk A., Łuczycka D.: *Wpływ kierunku wiatru na opad rozpylonej strugi cieczy użytkowej podczas opryskiwania płaskich upraw polowych*, Inżynieria Rolnicza, nr 120 (2), 2010, page 209-215.
18. Nuyttens D., de Schampheleire M., Verboven P., Brusselman E., Dekeyser D.: *Droplet size-velocity characteristics of agricultural sprays*, Trans. ASABE nr 52(5), 2009, page 1471–1480.
19. Özkan H. E.: *Technological Solution to Problems Associated with Application of Pesticides*, Jor. Of Agricultural Machines Sciences, nr 4(2), 2008, page 193-198.

20. Szewczyk A.: *Analiza ustawienia, parametrów i warunków pracy rozpylacza w aspekcie jakości opryskiwania upraw polowych*, Wydawnictwo Uniwersytetu Przyrodniczego we Wrocławiu, Wrocław, 2010, page 52-59.
21. Szewczyk A., Łuczycka D., Rojek G., Cieniawska B.: *Wpływ prędkości i typu rozpylacza na stopień pokrycia poziomych i pionowych powierzchni opryskiwanych*, Inżynieria Rolnicza, nr 4 (147), 2013, page 355-364.
22. Cieniawska B., Łuczycka D., Szewczyk A.: *Characteristics crop plants in the aspect of the process of spraying*, Mechanization in Agriculture, nr 6, 2014a, page 29-33.
23. Cieniawska B., Łuczycka D., Szewczyk A.: *The quality of procedure spraying on crops flat in the aspect of sprayed plants*, Mechanization in Agriculture, nr 6, 2014b, page 34-38.
24. Łuczycka D., Szewczyk A., Cieniawska B.: *Charakterystyka opryskowa wybranych roślin metodą graficzną*, Poznań, 2014, page 42-51.
25. www.rozpylacze-hypro.com/index_files/GuardianAIRTwin.htm [access: 31.01.2015 r.]
26. www.paulbparts.com/sprayer-parts/hypro-nozzles-tips-boom-compon/hypro-guardianair-twin-spray-n/hypro-guardianair-twin-sp [access: 31.01.2015 r.]
27. www.rozpylacze-hypro.com/pdfs/GuardianAIR-PL.pdf [access: 31.01.2015 r.]
28. www.spraypartswarehouse.com/ga-guardianair-hypro/fc-ga110-02-guardian-air-fastcap-110-2/ [access: 31.01.2015 r.]

29. Łuczycka, D., Szewczyk, A., Cieniawska, B.: *Nierównomierność pokrycia opryskiwanych obiektów wybranymi rozpylaczami jedno- i dwustrumieniowymi*, Inżynieria Rolnicza, nr 1(149), 2014), page 101-110.
30. Łuczycka D., Szewczyk A., Cieniawska B.: *Charakterystyka opryskowa roślin jako przydatne kryterium doboru rozpylaczy do zabiegu*, Zeszyty Problemowe Postępów Nauk Rolniczych, nr 577, 2014, page 93–102.

MSc Eng.Tomasz Klimza, Prof. Assoc. Antoni Szewczyk,
MSc Eng. Katarzyna Dereń[1)], PhD Beata Cieniawska,
MSc Eng.Tobiasz Wysoczański
Wrocław University of Environmental and Life Sciences
Department of Environmental Engineering and Geodesy
Safety Engineering
ul. C. K. Norwida 27, 50-375 Wrocław
[1)]katarzynaderen@up.wroc.pl

Deposition of the liquid as an index of the quality of a spraying plants in the literature

Keywords: *spray deposit, covering degree, coefficient surface sprayed plants, sprayer, spraying*

Summary: The paper presents an overview of issues related with the quality of the treatment plant spraying. Special attention was given to the application of spray liquid on the sprayed objects - one of the indicators of the quality of the completed procedure crop protection. Characterized other indicators of quality made spray: degree of coverage of sprayed surface and the uneven distribution of rainfall spray. Attention was drawn to the fact that without the use of chemical plant protection cannot be achieved effective food production - on which greatly increased demand both in Poland and in the world. Pesticides used in agriculture are useful, but they may also be harmful. Improper use of plant protection products could pose a serious threat to the aquatic and terrestrial ecosystems. The authors of many publications point to the danger of pesticides used for health and life of not only people but also animals and plants. Therefore, considerable attention in the literature devoted to issues of good made chemical plant protection treatments, which are indicators of the distribution of rainfall spray, the degree of coverage of sprayed objects and the deposition of liquid spray.

1. Introduction

The use of pesticides increases crop yields, thereby reducing the phenomenon of famine and reduces the cost of crop production [1]. The need to retain a high standard of yielding of crops, resulting from the economic viability of production, necessitates the use of large quantities of pesticides. From an economic point of view, chemical pesticide has a significant impact on the efficiency and quality of agricultural production [2]. Despite the positive aspects of what that gives you the use of pesticides, we must remember that their irrational use has a negative impact on the environment and humans. Plant protection products (PPP) because of their high diversity and availability are often the cause of many diseases, poisoning and sometimes death [3].

2. The effectiveness of the use of plant protection products

Plant protection products should be characterized by:

- selective toxicity (low to humans and other living organisms, a high for the pest)
- small durability,
- not accumulate in the environment,
- low price,
- simple storage.

The possibility of the use of chemical plant protection excludes the effect of carcinogenic or teratogenic [1,4].

Plant protection products should be used according to the product label - instructions for their use and the Rule of Good Agricultural Practice. Their application should be done always in a responsible and rational [5].

Biological efficacy of chemical preparations depends on the type and dose of preparation used, the amount of spray liquid per hectare, the development phase of the crop and plants competitive and the date of application [6,7,8,9]. Another important factor is the weather:

temperature, relative air humidity, wind speed and direction [10], as well as the physico-chemical properties of usable liquid (surface tension, viscosity of the liquid, the hardness of the water used, the addition of adjuvant [11,12,13,14]. According to Szewczyk (2000) factors describing the effectiveness of the biological preparations should also include the impact of technological and technical parameters, which include: the type of nozzle, pressure spray liquid, the height and speed of the spraying and the technical condition of the sprayer [15].

The accumulation of pesticides in the soil, and their penetration into the groundwater and the reservoirs may be due to the wrong choice of product or wrong treatment made spraying [16].

The main sources of environmental pollution by the pesticide contamination are point and drift use during surgery. Contamination point can be effectively reduced by proper handling of the remains of spray liquid and filling and storage of sprayers on special positions. Drift spray liquid can be reduced through the use of restrictive Elimination Techniques (TOZ) [17].

2.1. Control of pesticide residues

The use of plant protection products not only causes environmental pollution but also carries the risk of chemical residues in agricultural crops and food.

The consequence of this situation was to implement safety control systems of food products [18]. For a given chemical compound are determined maximum levels (NDP) for residues of plant protection in food product [19]. The European Union has imposed on member states the obligation to control pesticide residues in food verifying their proper application.

It is important that for the treatments of spraying fields of plant protection products to choose the proper preparation and dosage which will be applied technically efficient equipment, this will reduce the financial expenditure incurred on plant protection [20]. The faulty equipment used to perform the spraying, damaged nozzles, bad acting to stabilize the boom, leaks, faulty manometers can cause the environmental pollution by pesticides [21, 22]. Therefore, according to the Act of 18 December 2003 on plant protection (Journal of Laws of 2008, No. 133, item. 849, as amended. D.) sprayers are subjected to regular testing technical efficiency. These studies concern sprayers new and used trailed and self-propelled, field and orchard [5].

3. Plant protection products and the health of humans and animals

The most vulnerable people on the harmful effects of the pesticide are persons performing spraying plants. The reason for poisoning is often the inhalation of harmful substances for too long or bad protection workers spraying treatment plants. There are also cases of oral ingestion of the pesticide (eg. storage boxes of foodstuffs, preparation of chemicals in household utility vessels). Long lasting poisoning concern the persons regularly exposed to pesticides. Chemical compounds accumulated in the body affect carcinogenic processes, they are neurotoxin, disrupt hormonal regulation and enzymatic. Therefore, to prevent direct poisoning or the accumulation of plant protection chemicals in the body of humans and animals it is important to observe the withdrawal periods and prevention. [1,4, 23].

Threats to people, which entails the use of pesticides can be divided into direct (include farmers and workers producing pesticides) and indirect - which are exposed to consumers and bystanders. People are exposed to pesticides because they may get into the organism by various routes, e.g. for air, food, or drinking water [24].

The European Federation of Agricultural Workers' Unions (EAF) conducted a study that showed that the most common symptoms of poisoning of plant protection products are headache, abdominal pain, diarrhea and vomiting. US researchers found that people who perform treatment plant spraying more than 400 days a year passed by twice as likely to Parkinson's disease [25].

Contact with plant protection products may cause a variety of disease: impaired central of the nervous system, respiratory system, liver disease, stomach, kidney, skin lesions, cancer, impaired fertility, early births and abnormal development of the fetus [1, 26].

At the University of California at Berkeley conducted a study that showed that children prenatally exposed to pesticides have problems with learning and concentration during the postnatal (showing about 5 years old). Pregnant women exposed to pesticides have a higher concentration of organ phosphorus metabolites in the body. American and Australian researchers have demonstrated that the toxic preparations increase the risk of ADHD in children. [27]. At the University of Southern California in Los Angeles conducted research that showed increased (up to seven), the risk of developing lymphoma benign and more than 12-fold greater risk lymphoblastic lymphoma in children exposed to pesticides [28].

In the group most exposed to diseases caused by polluted for pesticides food or water are children less than 10 years of age. Possible health consequences of contact with pesticide residues and chemicals present in the environment, food and water include immunological effects, endocrine abnormalities, nervous disorders and cancer [24].

Plant protection products, as well as and their residues in the environment are also dangerous for animals. In 2009-2010 Łozowicka (2011) conducted research on the poisoning of plant protection products of bees. The researcher revealed that the failure by the farmers of the information contained on the labels of pesticides and the use of preparations not admitted to trading is the most common cause of extinction bee colonies. Particularly dangerous for the bees found the use of pyrethroid and insecticides. In one of the analyzed samples showed the presence of a prohibited use DDT compound. It may indicate a long term degradation of the substance. As you can see from the problem of environmental pollution, which is caused by the remnants of chemicals in soils we grapple for a long time. [29].

The highest concentration of harmful substances used in the treatment of plant protection is present during application and immediately after the end of treatment. The concentration of harmful substances in the air falls as a result of diffusion into the environment. [30]. By improper soil cultivation during the year in the world it will be washed out to the sea 25 million tons of earth (only 18% of that number is the erosion of chemical and physical). Soil erosion leads to total destruction or reduction of chemical activity, can also cause contamination of surface waters [31,32].

4. The quality of spraying plants

The quality of the spray depends on many factors. An important element of the sprayer affecting the quality of protective treatment plants is nozzle. To perform the application should choose the right type of nozzle, size and operating parameters (pressure, altitude, distance, setting). Choosing the right nozzle enables proper application of plant protection products and the expected coverage degree and spray deposit to the sprayed objects [33, 34, 35, 36; 37, 38,39].

One of the criteria used to evaluate the performance of nozzle is spray deposit liquid. Other no less important criteria for assessing the quality of spraying are: distribution of liquid fallout and the degree of surface coverage. These parameters can be determined in the laboratory and the field, which increases the usefulness of their use.

High quality treatment, increased productivity and elimination of threats to the environment and operators performing the treatments with plant protection products on this for years by the authors of the most important factors associated with the use of pesticides [40, 41, 42, 43, 44]. Quality made the protective treatment affects the size and quality of the obtained crop [45]. It is therefore essential properly performing treatments of chemical plant protection products.

4.1. Spray deposit

Spray deposit liquid is one of the most important indicators of the quality of the spraying session. Indicator spray deposit of liquid as quantitative parameter provides information not only on the quality but also the effectiveness of the treatment. Of spray deposit is defined as the ratio of the weight of fluid / formulation per unit area and is measured in micrograms substance sprayed on surface. [33, 35]. Indicator provides information on the actual dose of liquid / preparation as was used during the spraying the protective treatment, but does not provide information about the uniformity of the distribution of liquid on a sprayed surface [33, 47, 48]. So far, research on spray deposit liquid spray was conducted primarily in the cultivation of fruit. The most important factors that may affect the spray deposit of liquid are: The spray rate per unit volume of the crown; type sprayer; the distance between the sprayer and test facilities; matching the shape of the spray to the tree; operating speed; droplet size and wind speed and direction [49]. A very important factor is the phase phenological trees.

Świechowski et al. (2012) conducted a study whose purpose was to determine the effect of liquid dose and type of nozzle to spray deposit liquid in the crown of apple trees in different phenological phases. Based on the results, it was found that the greatest spray deposit of a fluorescent label in the crowns of apple trees were obtained during the flowering period. During treatments sprays of fine droplets obtained greater is spray deposit phase binding and the full education of the fruit. [50].

Research conducted spray deposit of Godyń et al. (2011) they relate to exposure to pesticides operator performing chemical treatment knapsack sprayer. The study involved two people, one experienced and one that did not have the ability to perform treatments. Experiments conducted in three types of cultivation: low (strawberry cultivation), medium (young orchard), and high (fruitful orchard). When measuring both operators were in protective suits, and on them arranged 13 measuring points in different areas of the body. Liquid, which operators spraying crops contain a fluorescent marker Brilliant Sulfo Flavine. After testing, it was found that spraying high crops is more dangerous for risk operator knapsack sprayer than treatments in medium and low crops. Operator exposure resulting from poor technical condition of the sprayer is higher in high crops than in medium or low [51].

To test spray deposit the liquid sample are usually used in the form of filter papers, and used in the study markers are the m. Al .: fluorescein, nigrosine, BSF - Brilliant Sulfo Flavine, copper oxychloride, or tartrazine [52, 49, 51, 53, 54, 55, 56]. In the analyzed results of the research on spray deposit of liquid it noted that previously used different methodologies for determining this parameter. Most often elected probes were the filtration membranes, and fluorescein tag.

4.2. Coverage of sprayed surface

Coverage of sprayed surface is another indicator weighs spray quality [57, 35]. To research the degree of coverage usually uses water sensitive paper. Water sensitive paper can be used for research in the field [34, 52] and laboratory [58] - are mounted directly to the leaf blades of the test plants. Water sensitive paper when tested in laboratory conditions it shall be attached to stand [59] or artificial plants [36]. The advantage of artificial plants is always a constant predetermined position in the papers so that the results are more reproducible and comparable [60].

In order to obtain the results of the coverage water sensitive papers are subjected to computer image analysis [61, 62, 63, 64, 65]. This method can be used not only in determining the the degree of coverage water-sensitive probes, but also for measuring the percent area of damaged plants by pests, for example. by discoloration leaves [66, 67, 68]. Research carried out so far have shown that there is a correlation between the degree of coverage and the effectiveness of the biological the protective treatment [33].

4.3. Distribution of spray

Another way to assess the quality of work applied to the treatment nozzle, a liquid distribution under the atomizer. This indicator depends on the use of nozzle. The larger hole spray nozzle to change the flow unit and more uneven spraying liquid. The presence of larger droplets increases the likelihood of runoff from sprayed surfaces [69, 70, 71]. Weather conditions (eg. Wind speed and direction), and the parameters performed the procedure (eg. working speed), also are important during fallout of liquid sprayed on objects [72, 10]

Studies distribution of sprayed liquid is performed through, for example wind tunnel. Szewczyk and Łuczycka (2010) in wind tunnel tests conducted nozzles two-stream. They have shown that the greatest effect on the test parameters were the type of nozzle used and the speed of the air stream [73].

Declercq et al. (2010), Czaczyk (2011) and Parafiniuk et al. (2011) conducted a study on the assessment of the technical condition of sprayers, as a factor that could decide the quality of spraying. Experiments carried out on the basis of the spectrum of spray distribution and spray fallout on the sprayed surface [74, 75, 76].

Lot of attention was to research the distribution section and longitudinal as an indicator of uneven distributions of liquid [77]. This indicator is important when considering the use of pesticides and the effectiveness of treatments.

5. Summary

In conclusion, it is worth noting that in many of the analyzed publications drew attention to the importance of knowledge of the characteristics of the nozzle, which in turn provides appropriate coverage and spray deposit of liquids on plants. Selection of the appropriate type of nozzle for the treatment reduces the excessive penetration of plant protection for the environment.

Based on the analysis of studies published in the literature it can be said that the high quality of the protective treatment plant spraying, rational use of pesticides, and to increase awareness of the risks which are inherent to the use of plant protection products can help to reduce pesticide residues in the environment and food products.

Quality made the treatment affects the size and quality of the obtained crop. It is therefore important to do a good plant health treatment. Indicator of the spray deposit liquid, a quantitative parameter provides information not only on the quality but also the effectiveness of the treatment.

Pesticides are useful, but they can also be harmful. They have a dominant role in agriculture because of the growing need for more efficient and sustainable, intensive food production. The inevitable presence of pesticides in the environment has forced scientists to better assess the current status and submit proposals to mitigate the adverse effects of the use of plant protection products.

References:

1. Walesiuk A., Wojewódzka-Żelazniakowicz M., Halim N., Łukasik-Głęboska M., Czaban S., Myćko G., Pazio L., Ładny J.: *Zatrucia środkami ochrony roślin*, Postępy Nauk Medycznych, nr 9, 2010, page 729-735.
2. Golinowska M.: *Ekonomika ochrony roślin w teorii i praktyce*, Progress in Plant Protection / Postępy w Ochronie Roślin, nr 49 (1), 2009, page 23-33.
3. Makles Z., Domański W.: *Ślady pestycydów – niebezpieczne dla człowieka i środowiska*, Bezpieczeństwo Pracy, nr 1, 2008, page 5.
4. Seńczuk W.: *Toksykologia współczesna*. Wyd. Lekarskie PZWL, Warszawa, 2005, page 24-26
5. Ustawa z dnia 18 grudnia 2003 r.. Ustawa o ochronie roślin (Dz. U. 2004 nr 11 poz. 94 z późn. zm.).
6. Krawczyk R.: *Aspekty stosowania obniżonych dawek herbicydów w zbożach jarych*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 46 (1), 2006, page 223-231.
7. Krawczyk R.: *Wpływ terminu stosowania zredukowanych dawek herbicydów w zbożach jarych na efektywność zwalczania chwastów*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 47 (3), 2007, page 151-158.
8. Krawczyk R.: *Obniżona dawka herbicydu – uwarunkowania, badania i praktyka*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 48 (2), 2008, page 621-627.
9. Matysiak K.: *Ocena stosowania obniżonych dawek wybranych herbicydów z grupy sulfonylomoczników w pszenicy jarej i jęczmieniu jarym*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 48 (3), 2008, page 1150-1155.

10. Szewczyk A., Łuczycka D.: *Wpływ kierunku wiatru na opad rozpylonej strugi cieczy użytkowej podczas opryskiwania płaskich upraw polowych*, Inżynieria Rolnicza, nr 120 (2), 2010, page 209-215.
11. Kierzek R., Wachowiak M., Kaczmarek S., Krawczyk R.: *Wpływ techniki ochrony roślin na skuteczność wykonywanych zabiegów*, Problemy Inżynierii Rolniczej, nr 17 (2), 2009, page 75-81.
12. Mandato S., Rondet E., Delaplace G., Barkouti A., Galet L., Accart P., Ruiz T., Cuq B.: *Liquids' atomization with two different nozzles: Modeling of the effects of some processing and formulation conditions by dimensional analysis*, Powder Technology, nr 224, 2012, page 323-330.
13. Orzechowski Z., Prywer J.: *Wytwarzanie i zastosowanie rozpylonej cieczy*, Wyd. WNT, Warszawa, 2012, page 156-158.
14. Woźnica Z.: *Współdziałanie adiuwantów a skuteczność chwastobójcza herbicydów*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 43 (1), 2012, page 473-497.
15. Szewczyk A.: *Parametry pracy opryskiwacza polowego a jakość pracy*, [w:] *Racjonalna Technika Ochrony Roślin*, Materiały Konferencyjne, 2000, page 163-173.
16. Oszmiańska M., Mielczarek M.: *Ochrona środowiska w gospodarstwach chłopskich*, Zeszyty Naukowe Akademii Rolniczej we Wrocławiu - Rolnictwo 137, nr 540, 2006, page 409-414.
17. Hołownicki R., Doruchowski G.: *Strefy ochronne o zróżnicowanej szerokości są konieczne*, [w:] *Racjonalna Technika Ochrony Roślin*, Materiały Konferencyjne, 2006, page 90-100.
18. Kucharski M.: *Pozostałości herbicydów w płodach rolnych badania monitoringowe z lat 1993-2006*, [w:] *Racjonalna Technika Ochrony Roślin*, Materiały Konferencyjne, 2007, page 45-50.

19. Łozowicka B.: *Studium nad pozostałościami środków ochrony roślin w płodach rolnych północno-wschodniej Polski*, Wyd. IOR - PIB, Poznań, 2010, page 177.
20. Kołodziejczyk R.: *Stan badań opryskiwaczy w Polsce w latach 2000-2007,* [w:] *Racjonalna Technika Ochrony Roślin,* Materiały Konferencyjne, 2007, page 69-74.
21. Czaczyk Z.: *Nierównomierność rozkładu poprzecznego cieczy i podatność wybranych rozpylaczy szczelinowych na zużycie,* Technika Rolnicza Ogrodnicza Leśna, nr 5, 2011, page 16-18.
22. Zasiewski P.: *Kryteria i dobór optymalnych parametrów pracy opryskiwaczy ciągnikowych. Część I –Opryskiwacze polowe*, [w:] *Racjonalna Technika Ochrony Roślin*, Materiały Konferencyjne, 2001, page190-197.
23. Król M., Panasiuk L., Szponar E., Szponar J.: *Ostre zatrucia*. *Rozdz. 8 Pestycydy*. Wyd. Lekarskie PZWL, Warszawa, 2009, page72-74.
24. Neumeister L.: *Pesticide Action Handbook. A Guide for Central and Eastern European NGOs ...and others*. PAN, 2003, Germany. ISBN 39808321-7-1.
25. Őzkan H. E.: *Current Status and Future Trends in Pesticide Application Technology.Proceedings of CIGR V conference,* Technology and Management to Increase the Efficiency in Sustainable Agricultura Systems, Rosario, Argentina, 2009, page 1-10.
26. Grosicka-Maciąg E.: *Biologiczne skutki stresu oksydacyjnego wywołanego działaniem pestycydów*, Postępy Higieny i Medycyny Doświadczalnej, nr 65, 2011, page 357-366.
27. Bouchard M. F., Chevrier J., Harley K. G., Kogut K., Vedar M., Calderon N., Trujillo C., Johnson C., Bradman A., Barr D., Eskenazi

B.: *Prenatal exposure to organophosphate pesticides and IQ in 7–year – old children*, Environmental Health Perspectives, nr 119(8), 2011, page 1189-1195.

28. Buckley J. D., Meadows A. T., Kadin M. E., Le Beau M. M., Siegel S., Robison L. L.: *Pesticide exposures in children with non –Hodgkin Lymphoma*, Cancer, nr 11(89), 2000, page 2315-2321.
29. Łozowicka B.: *Zatrucia pszczół środkami ochrony roślin i biocydami (2009 - 2010)*, Progress in Plant Protection/Postępy w Ochronie Roślin, nr 51(1), 2011, page 71-76.
30. Wrzosek J., Gworek B., Maciaszek D.: *Środki ochrony roślin w aspekcie ochrony środowiska*, Ochrona Środowiska i Zasobów Naturalnych, nr 39, 2009, page 75-88.
31. Mackay N., Terry A., Arnold D., Pepper T., Price O., Mason P.: *Approaches and Tools for Higher Tier Assessment of Environmental Fate*, Defra contract PL0546, 2004.
32. Poskrobko B.: *Zarządzanie środowiskiem*, Polskie Wydawnictwo Ekonomiczne, Warszawa, 2007, ISBN978-83-208-1713-3.
33. Hołownicki R., Doruchowski G., Świechowski W., Jaeken P.: *Methods of evaluation of spray deposit and coverage on artificial targets*, Electronic Journal of Polish Agriculture Universities, nr 5(1), 2002, page 1-9.
34. Lipiński A., Choszcz D., Konopka S.: *Ocena rozpylaczy do oprysku ziemniaków w aspekcie równomierności pokrycia roślin cieczą,* Inżynieria Rolnicza, nr 9(97), 2007, page 135-141.
35. Godyń A., Hołownicki R., Doruchowski G., Świechowski W.: *Ocena rozkładu cieczy opryskowej w sadzie jabłoniowym wykonana za*

pomocą papieru wodnoczułego. Inżynieria Rolnicza, nr 102 (4), 2008, page 299-306.

36. Szewczyk A., Łuczycka D., Cieniawska B., Rojek G.: *Porównanie stopnia pokrycia obiektów opryskiwanych wybranymi rozpylaczami eżektorowymi – jedno i dwustrumieniowym*, Inżynieria Rolnicza, nr 2(136), 2012, page 325-334.
37. Godyń A.: *Nowości w rozpylaczach do herbicydów*, Warzywa, nr 8, 2009, page 61-63.
38. Kierzek R.: *Skuteczna ochrona roślin [cz. II]. Dobór rozpylaczy do zabiegów polowych*, Ochrona Roślin, nr 1 (52), 2007, page 32-35.
39. Kierzek R.: *Wiele rozpylaczy, jeden oprysk*, Top Agrar, nr 7–8, 2008, page 118–121.
40. Tadel E.: *Technika ochrony polowych upraw wysokich ze szczególnym uwzględnieniem kukurydzy*, [w:] *Racjonalna Technika Ochrony Roślin*, Materiały Konferencyjne, 2007., page 100-106.
41. Oerke E., Dehne W., Schönbeck F., Weber A.: *Crop Production and Crop Protection: Estimated Losses in Major Food and Cash Crops*, Elsevier Science, 1994, ISBN 0444820957.
42. Őzkan H. E.: *Technological Solution to Problems Associated with Application of Pesticides,* Jor. of Agricultural Machines Sciences, nr 4(2), 2008, page 193-198.
43. Pruszyński S.: *Ochrona roślin -spojrzenie w przyszłość*, [w:] *Racjonalna Technika Ochrony Roślin*, Materiały Konferencyjne, 2003, page 5-16.
44. Szewczyk A.: *The impact of sprayer work parameters on field beam position in a vertical plane for some tractor-attached sprayers*,

Maintenance and Reliability, PAN, Lublin, 2002, nr 3 (15), page 13–18.

45. Szewczyk A.: *Wpływ ustawienia wybranych rozpylaczy na stopień pokrycia opryskiwanych powierzchni*, Inżynieria Rolnicza, nr 120 (2), 2010, page 201-207.
46. Nieróbca A., Zaliwski A., Horoszkiewicz-Janka J.: *Rozwój internetowego systemu wspomagania decyzji w ochronie zbóż*, Inżynieria Rolnicza, nr 125 (7), 2010, page 167-173.
47. Zhu, H., Dorner, J. W., Rowland, D. L., Derksen, R. C., & Ozkan, H. E.: *Spray penetration into peanut canopies with hydraulic nozzle tips*, Biosystems Engineering, nr 87 (3), 2004, page 275-283.
48. Gaskin R. E., Manktelow D. W. L., May W., Steele K. D.: *Technologies to maximise pre-flower spray applications to control scale on kiwifruit*, New Zealand Plant Protection, nr 62, 2009, page 266-270.
49. Godyń A., Hołownicki R., Doruchowski G., Świechowski W. 2006. Rozkład cieczy użytkowej w drzewach podczas opryskiwania sadu jabłoniowego. Inżynieria Rolnicza. 77 (2), 331-338.
50. Świechowski W., Doruchowski G., Godyń A., Hołownicki R.: *Naniesienie i pokrycie w drzewach jabłoni w zależności od dawki cieczy, wielkości stosowanych kropel oraz fazy fenologicznej*, Materiały Konferencyjne, 2012.
51. Godyń A., Doruchowski G., Hołownicki R., Świechowski W.: *Wpływ wysokości opryskiwanych roślin i stanu technicznego stosowanego opryskiwacza plecakowego na potencjalne zagrożenia dla środowiska przyrodniczego i operatora opryskiwacza*, Inżynieria Rolnicza, nr 133 (8), 2011, page 127-134.

52. Sánchez-Hermosilla J., Rincón V., Páez F., Fernández M.: *Comparative spray deposits by manually pulled trolley sprayer and a spray gun in greenhouse tomato crops*, Crop Protection, nr 31 (1), 2012, page 119-124.
53. Hołownicki R., Godyń A., Doruchowski G., Świechowski W.: *Naniesienie i straty cieczy użytkowej podczas opryskiwania wysoko formowanych drzew owocowych*, Agricultural Engineering, nr 2(137) T. 2, 2012, page 89-95.
54. De Souza Christovam R., Raetano C., de Amaral Dal Pogetto M., Prado E., Júnior H., Gimenes M., Serra M.: *Effect of Nozzle Angle and Air-Jet Parameters in Air-Assisted Sprayer on Biological Effect of Soybean Asian Rust Chemical Protection*, Journal of Plant Protection Research, nr 50 (3), 2010, page 347-353.
55. Celen I., Durgut M., Avci G., Kilic E.: *Effect of air assistance on deposition distribution on spraying by tunnel-type electrostatic sprayer*, African Journal of Agricultural Research, nr 4 (12), 2009, page1392-1397.
56. Larsolle A., Wretblad P., Westberg C.: *A comparison of biological effect and spray liquid distribution and deposition for different spray application techniques in different crops*, Uppsala, 2002, ISSN 00283-0086.
57. Zhu H., Rowland D.L., Dorner J.W., Derksen R.C.: *Infuence of Plant Structure,Orifice Size and Nozzle Inclination on Spray Penetration into Peanut Canopy*, Trans. of the ASAE, nr 45(5), 2002, page 1295-1301.
58. Foqué D., Braekman P., Pieters J. G., Nuyttens D.: *A vertical spray boom application technique for conical bay laurel (Laurus nobilis) plants*, Crop Protection, nr 41, 2012. page 113-121.

59. Derksen R., Frantz J., Ranger C., Locke C., Zhu H., Krause C.: *Comparing Greenhouse Handgun Delivery to Poinsettias by Spray Volume and Quality*, Transaction of the ASABE, nr 51 (1), 2008, page 27-35.
60. Szewczyk A.: *Analiza ustawienia, parametrów i warunków pracy rozpylacza w aspekcie jakości opryskiwania upraw polowych*, Wyd. Uniwersytetu Przyrodniczego we Wrocławiu, Wrocław, 2010.b, ISBN 978-837717-003-8, page 63-105.
61. Abbaspour-Fard M., Daneshjoo A., Aghkhani M., Arian M.: *Introducing easy to use and accurate image processing object detection algorithms suitable for sprayer calibration and other similar purposes*, Journal of Agricultural Machinery Science, nr 4 (2), . 2008, page 199-204.
62. Cunha M., Carvalho C., Marcal A.: *Assessing the ability of image processing software to analyse spray quality on water-sensitive papers used as artificial targets*, Biosystems Engineering, nr 111 (1), 2012, page 11-23.
63. Fox R. D., Derksen R. C., Krause C. R., Cooper J. A., Őzkan H. E.: *Visual and image system measurement of spray deposits using water-sensitive paper*, Appl. Eng. Agric., nr 19(5), 2003, page 549-552.
64. Lipiński A. J., Lipiński S.: *Automatyczna ocena jakości oprysku na podstawie śladów kropel przy użyciu komputerowej analizy obrazu*, Inżynieria Rolnicza, nr 5(114), 2009, page 163-168.
65. Thomson S., Lyn M.: *Environmental and spray mixture effects on droplet size represented by water-sensitive paper used in drift studies*, Transaction of the ASABE, nr 54 (3), 2011, page 803-807.

66. Chojnacki J., Tomkiewicz D.: *Ocena koncentracji owadobójczych nicieni w cieczy roboczej za pomocą komputerowej analizy obrazu*, Inżynieria Rolnicza, nr 10(108), 2008, page 31 - 38.
67. Łuczycka D.: *Wykorzystanie komputerowej analizy obrazu do oceny stopnia uszkodzenia roślin przez szkodniki*, [w:] *Racjonalna Technika Ochrony Roślin*, Materiały Konferencyjne, 2002, page 201-205.
68. Rut J., Szwedziak K.: *Zastosowanie akwizycji obrazu do szacowania strat w uprawie ziemniaka*, Inżynieria Rolnicza, nr 7(105), 2008, page 179-184.
69. Koszel M, Sawa J.: *Wpływ parametrów pracy rozpylaczy płaskostrumieniowych na spektrum śladu kropel*, Inżynieria Rolnicza, nr 5, 2006, page 313-319.
70. Koszel M., Hanusz Z.: *Porównawcza analiza natężenia wypływu cieczy z rozpylaczy płaskostrumieniowych*, Inżynieria Rolnicza, nr 1(99), 2008, page 195-200.
71. Koszel M.: *Ocena jakości oprysku w sytuacji różnego stopnia zużycia i różnych eksploatacyjnych parametrów rozpylaczy płasko strumieniowych*, Inżynieria Rolnicza, nr 8(117), 2009, page 55-60.
72. Szewczyk A., Wilczok G.: *Teoretyczny opis rozkładu rozpylanej cieczy w warunkach działania czołowego strumienia powietrza*, Inżynieria Rolnicza, nr 5(103), 2008, page 292-299
73. Szewczyk A., Łuczycka D.: *Rozkład opadu rozpylonej cieczy wybranymi rozpylaczami dwustrumieniowymi w warunkach działania czołowego strumienia powietrza*, Inżynieria Rolnicza, nr 122 (4), 2010, page 213-220.
74. Declercq J., Huyghebaert B., Nuyttens D.: *An overview of the defects on tested field sprayers in Belgium*, Proceedings 3rd European

Workshop on Standardised Procedure for the Inspection of Sprayers in Europe – SPISE, nr 3, 2010, page 157-163.

75. Czaczyk Z.: *Nierównomierność rozkładu poprzecznego cieczy i podatność wybranych rozpylaczy szczelinowych na zużycie*, Technika Rolnicza Ogrodnicza Leśna, nr 5, 2011, page 16-18.
76. Parafiniuk S., Sawa J., Wołos D.: *Automatyczne urządzenie do oceny stanu technicznego rozpylaczy rolniczych*, Postępy nauki i techniki, nr 10, 2011, page 39-48.
77. Nowakowski T.: *Zmiany kąta rozpylenia w zależności od ciśnienia cieczy*, Technika Rolnicza, Ogrodnicza i Leśna, nr 2, 2007, page 14-15.

Alona Perebynos[1)],Tetyana Kryvomaz
Kyiv National University of Construction and Architecture
31, Povitroflotsky Avenue, Kyiv-037, 03680 Ukraine
Andriy Chuyenko
D.K. Zabolotny Institute of Microbiology and Virology of the NASU,
154 Acad. Zabolotny page, Kyiv, 03680 Ukraine
[1)]alenaperebinos@gmail.com

Fungi in air and on wooden constructions of old historical building

Key words: *microfungi, wooden destruction, mycotoxins, building.*

Summary: In this research the microfungi biodestruction of wooden constructions in the historical building was analyzed. Since the main artifacts in the Museum of Folk Architecture and Life of Ukraine "Pyrogovo" are built of wood, they are extremely vulnerable to the action of biological agents, especially microfungi. The house of village Samary from Volyn region, which is the most ancient artifact in the museum, was examined to identify the fungi spectrum on the wood and in the air. 20 samples of building constructions and 8 air samples have been collected inside and outside the studied house. In total, 11 species and genus (35 specimens) of microfungi were identified from 20 samples of building constructions of the studied house. 25 fungi specimens belonging to 6 species (*Aspergillus niger, Alternaria tenuissima, Chaetomium globosum, Mycelia sterilia, Stachybotrys chartarum, Trichoderma viride*) and 4 fungi which was possible identified only to genus *Acremonium, Fusarium, Mocladium* and *Penicillium* were found on wood walls. The most abundant species of the Samary house on the construction substratum were *Aspergillus niger* and *Alternaria tenuissima,* in the air - *Aspergillus flavus, A. repens, A. niger* and *Alternaria tenuissima.*

1. Introduction

Open-air museums are not only one of the most common ways to preserve the cultural heritage of the people, but there are research institutions that collect monuments of material and spiritual culture. Also skasen is kind of liaison with the people through scientific and educational activities, such as organizing shows, exhibitions, revival of handicrafts, etc. That is why the museum was and remains the real treasure of folk culture and knowledge from antiquity to the present. The current stage of development of the open-air museum is marked quantitative growth and spread throughout Europe. This is largely due to the fact that they have more opportunities in today's information space as covering not only individual monuments with their exposure, but also the spatial environment that can be converted depending on the design decisions of scientists, architects and museum workers [1].

Museum of Folk Architecture and Life of Ukraine "Pyrogovo" is one of the largest open-air museums (skansen) in the world. The museum creation was started in 1969 with funds Ukrainian Society for Protection of Historical and Cultural Monuments and grand opening was held on July 7, 1976. Its architectural ensemble is made up of 6 historical-ethnographic regions of Ukraine: Naddnipryanschina, Slobozhanschina, Polissia, Carpathians, Podillia and South Ukraine, which provide more than 300 architectural exhibits, among them Ukraine's largest collection of windmills and almost 80.000 items life and works of folk art [2, 3]. Skansen expositions reflect the material and spiritual culture of the nation, so preserving the national heritage for future generations is one of the priority directions of the development of any country.

Since the main artifacts in the museum are built of wood, they are extremely vulnerable to the action of biological agents. Factors affecting the operation of architectural monuments may be divided into: abiotic (temperature fluctuations, rain, UV radiation, wind load, etc.) and biotic (fungi, insects, algae, bacteria, etc.). Mycological (fungi) and entomological (insect) damage of wooden structures are the most common among biological effects and require considerable expenses for the restoration [4-6]. Considering that the museum "Pyrogovo", like most open-air museum, is also a recreational zone, so a constant monitoring will ensure not only the preservation of cultural heritage, but also ecological safety of the area.

1.1. Mycodestruction

Biodegradation is a special type of corrosion-aggressive impact of the environment, based on the influence of living organisms and their metabolic products in the material. Microorganisms that get the surface structures such as fungi (mycodestruction) form enzymes in the life activity that in the interaction with cellulose materials transform their constituents in more available organic compounds (water and carbon dioxide). Usually the end result of this process is the organic matter destruction, i.e. change the anatomical structure of the material and the loss of proper physical and mechanical properties [7-9].

Fungi are always present in the environment as spores and other structures. In the wood fungi get during the growth of trees, timber harvesting, storage, production and operation. However, the damaging effect of fungal agents occurs only under certain conditions. Subsidence of fungal spores in the wood is actually a continuous process, but the intensity can vary seasonal intervals. Spores capable to the surface adhesion and can penetrate by invisible structural breach of wood to deeper layers, while maintaining its viability over decades and start actively functioning in the event of a favorable environment for their development. Although the effect of factors such as the appropriate temperature and humidity, the lack of light and air flows, the availability of substrate is required for activity of all fungi, but the output from rest takes place only in individual conditions for each species and even strain [10]. In this regard, it is extremely difficult to navigate at the time of occurrence of damage, its root causes and predict the direction and speed of the process.

Damage of the material by microorganisms is a complex process that may be characterized by six stages [11, 12]:

1) transfer microbial spores from the air, water and soil environment;
2) adhesion microbial spores;
3) emergence and growth of micro colonies that are visible with the naked eye and the appearance of corrosive metabolic products;
4) impact of metabolic products on the material;
5) stimulation of corrosive damage related biodegradation;
6) synergy of biodegradation process whose essence is in appearing functional relationships between existing microorganisms on the surface of the material that substantially affect the process of material damage and change its original course [10, 13, 14].

The peculiarity and complexity in the study of cellulose materials is the inability to guarantee that current changes in physical and mechanical properties associated only with the influence of microorganisms. Often, signs of microbial activity on the surface of wooden structures may be due to the influence of abiotic environmental factors (temperature, humidity, etc.) or mechanical stress. In this regard, the model of laboratory experiments with playing a real character of microbiological damage is recommended to confirm the presence and quantitative assessment of the participation of microorganisms in the change process of material properties [10].

The first stage of wood damaging happens with representatives of the department of Ascomycota and anamorphic fungi that use readily available timber components (reserve carbohydrates and other compounds). These fungi destroy the internal contents of cells, substantially without affecting the structure of cell walls, i. e. not decompose lignin cellulose complexes that form the bulk of the timber. Mycological agents of the primary destruction is mostly wood-staining fungi that feed on contents of dead sapwood cells. Settling timber of wood-staining fungi can occur at temperatures from 5 to 30 °C and humidity over 22%. Usually fungi development continues until the wood keeps the natural moisture. After it dries the viability of fungi almost completely stops. The second stage of wood damage is carried out mainly involving bracket fungi and other xylotrophic fungi which may destroy hard-polymer (lignin and cellulose). These fungi are agents of brown and white rot. The final, third stage of wood degradation lasts for decades. It involved a xylotrophic and saprotrophic nutrition. Overall, the rate of wood decomposition depends on various factors: the type of wood, its position in the design, temperature, humidity, and so on [9, 11].

1.2. Effect of mycodestructors on human health

A large number of microscopic fungi (micromycetes) can synthesize mycotoxins and other poisons that have harmful impact on human health, cause deterioration in physiological state and reduce the body's resistance against diseases. Mycotoxins are secondary metabolites, i.e. they appear to have no role in the normal metabolism involving growth of the fungus, and able to initiate allergic or toxic reactions in humans even at low concentrations.

Fungal metabolites mainly fall into the human body in three ways: orally (with an infected food), inhalation (breathing in spores of toxigenic fungi) or by direct contact through the skin [16, 17]. Mycotoxins have four basic kinds of toxicity: acute, chronic, mutagenic and teratogenic [18]. Their toxicity and properties depend on the chemical structure and concentration [17], and the level of production - from the humidity of the substrate and heat conditions. The relationship between the presence of microscopic fungi in the room and the health of residents of buildings generally appear by allergic reactions of varying intensity as rhinitis, asthma, allergic pneumonitis, and various unpleasant and painful health problems largely of unknown etiology such as frequent bronchitis, chronic cough, and irritation [19, 20].

Toxic effects of mycotoxins on health called mycotoxicoses. The symptoms of mycotoxicoses are almost as diverse as the chemical structures of the compounds themselves. Some compounds may elicit few symptoms until death results, while others may produce severe effects including skin necrosis, leucopoenia and immunosuppression. Doses producing chronic disease are usually far below those responsible for acute effects, and so long-term effects such as cancer or tumor induction are undetected at the time of ingestion and, indeed, may remain so until disease is quite advanced [18].

Mycotoxicoses are examples of “poisoning by natural means” and thus are analogous to the pathologies caused by exposure to pesticides or heavy metal residues. The symptoms of a mycotoxicosis depend on the type of mycotoxin; the amount and duration of the exposure; the age, health, and sex of the exposed individual; and many poorly understood synergistic effects involving genetics, dietary status, and interactions with other toxic insults. Thus, the severity of mycotoxin poisoning can be compounded by factors such as vitamin deficiency, caloric deprivation, alcohol abuse, and infectious disease status [16, 21].

2. Materials and methods

For this research was chosen a wooden house of village Samary, Volyn region. The exhibit was moved to the National Museum Pyrogovo in 1970, but it was built in 1587. This building is the most ancient artifact in the museum and a rare example of traditional polisky construction. The Samary house is a single-chamber building with total area in 24.5 m^2. It has pine wood walls, a straw roof and soil clay floor.

The study was performed in two stages. The first phase consisted of a preliminary visual inspection of the building and describing the monument, which are marked in the mechanical characteristic features (cracks, crumbling, peeling), entomological (tracks of beetles, web) and microbial damage (raids, colonies, stains, changes in color of wood). Initial inspection algorithm also took into account the presence of leaks, dust, humidity and ventilation. The inspection of buildings has been carried out to identify the damage and determine areas of sampling.

After determining locations of sampling, the second phase that consisted of a field (sampling) and laboratory (identification of fungus type) stages was started. Sampling has been performed by the method of selecting fragments of wood, putty, straw or soil. Samples have been taken under the conditions of sterility of the walls, ceiling, floor and door inside and outside the building, on the surface which visually ascertained damage or suitable conditions for its occurrence. Then samples grow in laboratory. Isolated cultures of fungi have been identified with standard microscopic technics using determination keys [22-25].

For comparison, air samples from outside and inside the building have been taken. The air samples has been selected by sedimentation method: Petri dishes with a dense nutrient environment are left open in the field of research on 15 minutes, then closed dishes are transferred to a thermostat for 24 hours, maintained same time at room temperature and count the number of colonies that grew. Five air samples have been selected inside (at the corners and center of the building) and three – outside the house (placed randomly).

3. Results and Discussion

20 samples of building construction have been collected inside and outside the studied house (Table 1). In total, 11 species and genus (35 specimens) of microfungi were identified from 20 samples of building constructions of the studied house. 20 fungi specimens were found on substratum outside the house and 15 – inside.

Table 1. List of construction samples collected inside and outside the house with identified microfungi

Samples collected inside and outside the house		
№	Description of the sample location	Fungi species or genus identified from this sample
1	Soil floor	*Alternaria tenuissima*

2	Wall 1 with signs of destruction	-
3	Wall 2, wood has stains from leaking and black dots	*Mocladium* sp. 1
4	Ceiling, spot left in the center	*Aspergillus niger*, *Mocladium* sp. 1
5	Wall 3 with stains from leaking	*Acremonium* sp. 1
6	Wall 4 with a spot of leaking (restored part of the wall)	*Mocladium* sp. 1, *Acremonium* sp. 1, *A. tenuissima*, *Penicillium* sp. 1, *Mycelia sterilia* (yellow)
7	Ceiling, sample with putrid wood	*Penicillium* sp. 2
8	Wall 1, wood & clay	*Alternaria tenuissima, Alternaria alternata*
9	Ceiling, wood with visible damage	*Fusarium* sp. 1
10	Ceiling, wood with white spots	*A. niger*
	Samples collected outside the house	
№	Description of the sample location	Fungi species or genus identified from this sample
11	Door	*Aspergillus niger*
12	Wall 1 (wood)	*A. niger*
13	Wall 4 (wood)	*A. niger, Chaetomium globosum, Stachybotrys chartarum*
14	Wall 4 (wood)	*A. niger, S. chartarum*

15	Wall 3 (putty)	*A. niger, Alternaria tenuissima*
16	Wall 3 (wood)	*A. niger, Alternaria tenuissima*
17	Wall 2, wood with black spots	*A. niger, Trichoderma viride,*
18	Wall 2 (wood)	*A. niger, Alternaria tenuissima*
19	Roof (inside the thatch)	*A. niger, Alternaria alternata*
20	Roof (outside the thatch)	*A. niger, C. globosum, Mycelia sterilia* (orange)

Source: Own

Despite of the wood destruction from which a sample 2 was taken, it did not bring any result, may be because location near door provide a fresh air inflow, which don't give condition for fungi spores accumulation and species developing. Surprisingly, that a sample 6 from fresh wood wall brought more rich fungi diversity then completely destroyed fragment of old wood. It was expected that destroyed wood construction accumulate fungi spores and structures, but more high diversity of species on fresh wood can be explain by constant water leakage in this place. It is show high importance such factor as humidity for fungi developing.

Only in 3 of 9 samples taken from wooden structures inside the building were found species of fungi, known as destructors of wood. Namely, from a sample 2 (spot of unknown origin on the ceiling) was identified *Aspergillus niger*, a sample 8 (wood with clay that was be white spots of unknown origin on the ceiling) - *Aspergillus niger*. However, it is not possible to be sure that these species are cause of damages. For confirmation is necessary to study of the damage process in the laboratory. In all 10 samples that were taken outside the house were found well known destructors of wood, such as *Aspergillus niger* (all 10 samples), *Alternaria alternate* (sample 19), *Stachybotrys chartarum* (samples 13, 14), *Chaetomium globosum* (samples 13, 20) and *Trichoderma viride* (sample 17).

25 fungi specimens belonging to 6 species (*Aspergillus niger, Alternaria tenuissima, Chaetomium globosum, Mycelia sterilia, Stachybotrys chartarum, Trichoderma viride*) and 4 fungi which was possible identified only to genus *Acremonium*, *Fusarium*, *Mocladium* and *Penicillium* were found on wood walls. Five specimens belonging to four species: *Alternaria alternata, Chaetomium globosum*, *Mycelia sterilia* and *Aspergillus niger* were found on the thatch. Two specimens belonging to 2 fungi species were found on the wood and clay (*Alternaria alternate* and *A. tenuissima*) and on the putty (*Aspergillus niger*, *Alternaria tenuissima*). And only one specimen *Alternaria tenuissima* was on the soil floor (Fig. 1).

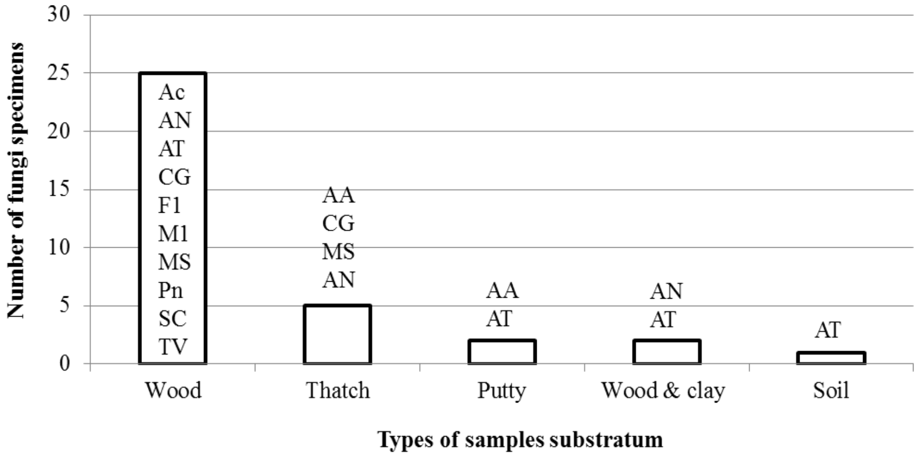


Figure 1. Spreading of fungi specimens on substratum samples (fungi name acronyms as in table 3)

Source: Own

On wall find 23 fungi specimens belonging to 7 species (*Alternaria alternate, Aspergillus niger, Alternaria tenuissima, Chaetomium globosum*, *Mycelia sterilia, Stachybotrys chartarum*, *Trichoderma viride*) and 4 fungi which was possible identified only to genus *Acremonium*, *Mocladium* and *Penicillium.* Five specimens belonging were finding on ceiling and roof. In first case it were *Aspergillus niger* and 3 fungi which was possible identified only to genus: *Fusarium*, *Mocladium* and *Penicillium.* Specimens on roof belong to 4 species - *Alternaria alternate, Aspergillus niger, Chaetomium globosum* and *Mycelia sterilia*. Only by one specimens from one species were identified from the floor (*Alternaria tenuissima*) and door (*Aspergillus niger*) (Fig. 2)

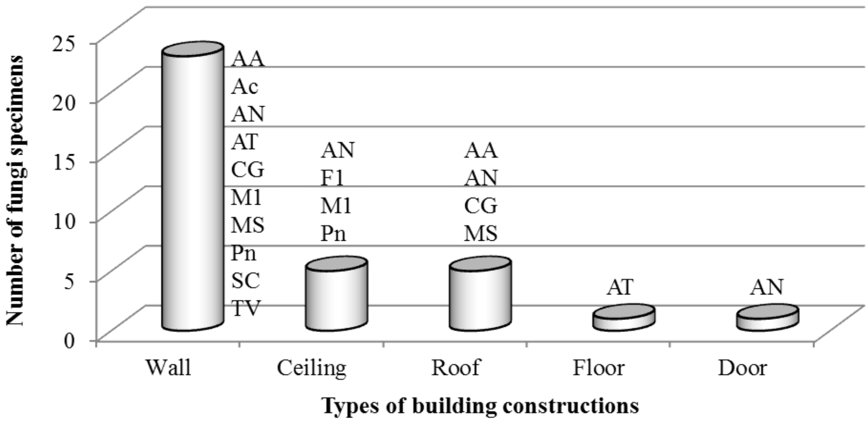


Figure 2. Spreading of fungi specimens on the building constructions of the studied house (fungi name acronyms as in table 3)

Source: Own

From 7 air samples were received 11 species and 5 genera (30 specimens) of microfungi (Table 2). The 8th air sample that was selected outside did not give any results, therefore was not included to the table. 22 fungi specimens belonging to 8 species (*Aspergillus niger*, *A. flavus*, *A. repens*, *A. parasiticus*, *Alternaria tenuissima*, *Mycelia sterilia*, *Absidia spinose* and *A. glauca*) and 5 fungi which were possible identified only to genus *Phoma*, *Fusarium*, *Penicillium*, *Alternaria* and *Trichoderma* were received from air samples taken inside the house. 8 specimens belonging to 7 species (*Rhizopus stolonifer*, *Aspergillus niger*, *A. flavus*, *A. repens*, *Mucor mucedo*, *Trichoderma viride* and *Alternaria tenuissima*) and 1 genus *Fusarium* were identified from air samples taken outside the house.

Table 2. List of microfungi identified from air samples inside and outside the house

№ sample	Fungi species or genus identified from this sample	The concentration of spores, CFU/m^3		
		bacteria	fungi	total

Inside the house				
1	*Phoma* sp.	364	332	696
2	*Aspergillus niger, A. flavus, A. repens,* *Penicillium* sp., *Fusarium* sp., *Alternaria tenuissima, Mycelia sterilia* (orange)	-	844	844
3	*A. flavus, A. repens, Penicillium* sp., *Alternaria* sp., *Trichoderma* sp.	-	1232	1232
4	*A. flavus, A. repens, Mycelia sterilia* (orange), *Alternaria tenuissima*	-	732	732
5	*A. flavus, A. niger, A. parasiticus, Absidia spinose, Absidia glauca*	64	252	316
Outside the house				
1	*Trichoderma viride, Aspergillus niger, A. flavus,* *Alternaria tenuissima*	120	556	676
2	*Rhizopus stolonifer, A. repens, Fusarium* sp., *Mucor mucedo*	32	292	324

Source: Own

The number of microscopic fungi in the premises is one of the most important indicators of air quality. This index is estimated by the number of colony forming units (CFU) per cubic meter. Analysis of air samples in the surveyed house indicates that the number of microscopic fungi in certain points of measurements ranged from 252 to 1232 CFU/m^3 inside the house. The highest concentration of spores was obtained from the 3rd sample, which was taken at the center of the research area. Other Petri dishes were placed in the corners, so the results are much smaller, which may explain the more intense air flow due to the gaps in the walls. The concentrations of spores were obtained with only 2 of 3 selected samples outside the house. Their measurement are 292 and 556 CFU/m^3 and have no significant difference.

Regarding the concentration of bacteria spores: insignificant concentration levels were detected in 2 of 5 samples inside the house and in 2 of 3 outside the house. 4 samples may gave no results because of improper conditions for the development of spores that were in the Petri dish. It is also possible that the spores were simply absent in these samples and for more detailed investigation was necessary to use another method of air sampling for microbiological analysis. The role of bacteria in wood degradation is less important because they require a higher water content and have been found mainly in outdoor air samples.

Although airborne bacterial concentrations are usually higher than fungi, in this research there was a different picture. For the indoor air samples, the concentration of total fungi (88%) was higher than the concentration of total bacteria (11%) for all the areas (Fig. 3). For the outdoor air samples, the concentration of total fungi (85%) was also higher than the concentration of total bacteria (15%) (Fig. 4). Also the indoor bacterial concentrations (74%) were significantly higher than the outdoor bacterial concentrations (26%).

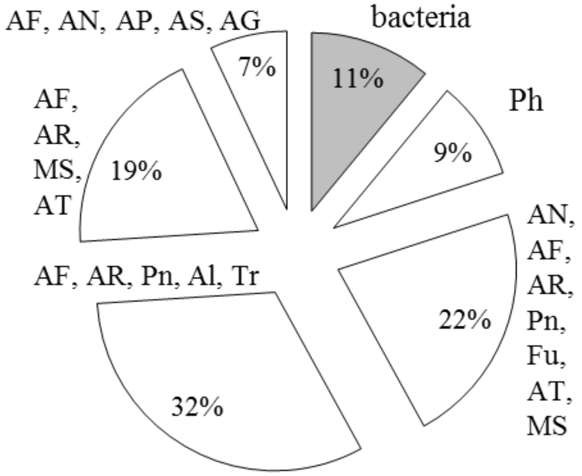


Figure 3. The concentration of spores microfungi and bacteria inside the house (fungi name acronyms as in table 3)

Source: Own

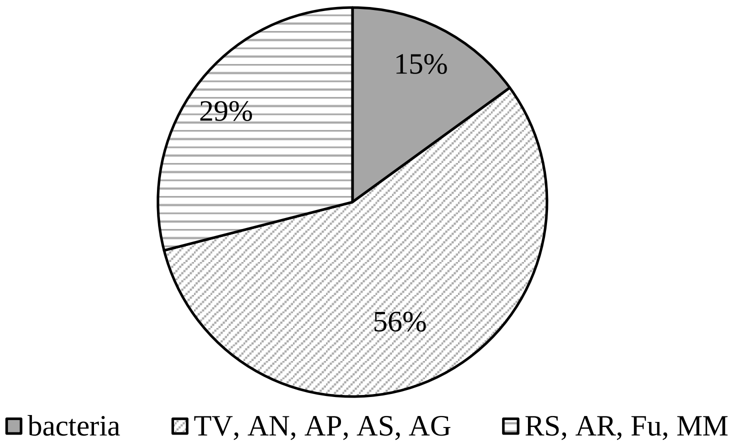


Figure 4. The concentration of spores microfungi and bacteria outside the house (fungi name acronyms as in table 3)

Source: Own

From air and house construction substrates in total 21 species and genus were indentured (Table 3). Common for air and substratum was 6 species (29%), only 10 species (47%) was registered in the air, and 5 species (24%) were found on house constructions. Inside and outside of the house 33% of specimens belonging to 6 species *Alternaria alternata, A. tenuissima, Aspergillus flavus, A. niger, A. repens, Mycelia sterilia* and one fungi which was possible identified only to genus *Fusarium* were registered.

Table 3. List of microfungi identified from construction and air samples inside and outside the building

№	Fungi species or genus	Fungi name acronym	Number of fungi specimens					
			on constructions			in air		
			inside	outside	total	inside	outside	total
1	*Absidia glauca*	AG	-	-	-	1	-	1
2	*A. spinose*	AS	-	-	-	1	-	1
3	*Acremonium sp.*	Ac	2	-	2	-	-	-
4	*Alternaria alternate*	AA	1	1	2	-	-	-
5	*A. tenuissima*	AT	3	3	6	2	1	3
6	*Alternaria* sp.	Al	-	-	-	1	-	1
7	*Aspergillus flavus*	AF	-	-	-	4	1	5
8	*A. niger*	AN	2	10	12	2	1	3
9	*A. parasiticus*	AP	-	-	-	1	-	1
10	*A. repens*	AR	-	-	-	3	1	4
11	*Chaetomium globosum*	CG	-	2	2	-	-	-
12	*Fusarium* sp.	F	1	-	1	1	1	2
13	*Mocladium* sp.	M1	3	-	3	-	-	-
14	*Mucor mucedo*	MM	-	-	-	-	1	1

15	*Mycelia sterilia*	MS	1	1	2	2	-	2
16	*Penicillium* sp.	Pn	2	-	2	2	-	2
17	*Phoma* sp.	Ph	-	-	-	1	-	1
18	*Rhizopus stolonifer*	RS	-	-	-	-	1	1
19	*Stachybotrys chartarum*	SC	-	2	2	-	-	-
20	*Trichoderma* sp.	Tr	-	-	-	1	-	1
21	*Trichoderma viride*	TV	-	1	1	-	1	1
	TOTAL		15	20	35	22	8	30

Source: Own

Inside the house only 43% specimens were accumulated, which are belonging to 3 species *Absidia glauca, A. spinose, Aspergillus parasiticus* and 6 fungi which was possible identified only to genus *Acremonium, Alternaria, Mocladium, Penicillium, Phoma, Trichoderma*. Outside the house only 24% specimens were found, which belong to 5 species *Chaetomium globosum, Mucor mucedo, Rhizopus stolonifer, Stachybotrys chartarum* and *Trichoderma viride.*

The most abundant species on the construction substratum was *Aspergillus niger* and *Alternaria tenuissima,* in the air - *Aspergillus flavus, A. repens, A. niger* and *Alternaria tenuissima*. The spectrum of fungi in building samples was very different from that observed in air. The number of species observed in material samples was low compared to air samples. This may have been partly caused by different laboratory conditions during growing samples. Also it is show that not all spores from air will develop on wood, but need remember that some of this spores can be cause of allergy and other disease for people. Of all the identified fungi can damage the wood following: *Aspergillus niger* causes black mold; *Aspergillus flavus* - cancerogenic mold; *Alternaria alternate* - toxic mold and blue stains; *Stachybotrys chartarum* - toxic mold; *Trichoderma viride* cases mold and produces enzymes [11].

4. Conclusions

1. In total, 11 species and genus (35 specimens) of microfungi were identified from 20 samples of building constructions of the studied house. 20 fungi specimens were found on substratum outside the house and 15 – inside.
2. 25 fungi specimens belonging to 6 species (*Aspergillus niger, Alternaria tenuissima, Chaetomium globosum, Mycelia sterilia, Stachybotrys chartarum, Trichoderma viride*) and 4 fungi which was possible identified only to genus *Acremonium, Fusarium, Mocladium* and *Penicillium* were found on wood walls.
3. From 7 air samples was received 11 species and 5 genera (30 specimens) of microfungi – 22 specimens inside and 8 outside of the house.
4. The most abundant species on the construction substratum was *Aspergillus niger* and *Alternaria tenuissima,* in the air - *Aspergillus flavus, A. repens, A. niger* and *Alternaria tenuissima*.

References:

1. Bashkatov, Yu. Yu., Terpylovsky, R. V.: *To the history of scansens in Europe*. Archaeology and ancient history of Ukraine: ІА НАНУ, 5, 2011, page 7-16.
2. Prybiega, L.: To the creation history of the architectural exposition of the Museum of Folk Architecture and Life of Ukraine. Echo of ages, 1(11), 2009, page 14-18.

3. Danyliuk, A.: *Ukrainian Skansens. History of origin, expositions and development problems*. Ternopil, Ukraine: Dogdan, 2006, page104.
4. Ilichev, V. D., Bocharov, B. V., & Gorlenko, M.V.: *Ecological bases of protection against biological damage.* V. E. Sokolova (Ed.). Moscow: Science, 1985, page 264.
5. Pyatnitskaya, T. A.: *Real-time monitoring of architecture monuments. Bulletin* MGSU, Issue 8, 2011, page. 28–32.
6. Knyazeva, V. P.: *Ecology. Restoration Basics: Textbook for High Schools.* Moscow: Architecture, 2005, page 399.
7. Vlasov, D. Y.: *Biodegradation of building materials and ways to protect against biocorrosion*. Alitinform, 4–5 (11), 2009, page 5–11.
8. Vanin, S. I.: *Forest phytopathology*. Moscow, Russia: Goslesbumizdat, 1955, page 416.
9. Antoniak, G. L., Kalynets-Mamchur, Z. I., Dudka, I. A., Babich, N. O., & Panas, N.E.: *Ecology of fungi*. Lviv: Ivan Franko National University of Lviv, 2013, page 628.
10. Koval, E. Z., & Mytkivska, T. I.: *Mycological investigation of museum artifacts*. Kyiv, Ukraine, 2011, page 232.
11. Schmidt, O.: *Wood and tree fungi.* Springer-Verlag Berlin Heidelberg, 2006, page 334.
12. Varchenko, E. A.: *Estimation of biodegradation and bio-corrosion of materials in natural environments*. Scientific Journal of KubSAU, 104 (10), 2014, page 1948–1965.
13. Kats, N. G., Starikov, B. P., & Parfenova, S. N.: *Chemical resistance of materials and protection of the oil and gas refining equipment from corrosion.* Moscow. Russia: Mechanical engineering, 2011, page 436.

14. Iverson, W. P.: *Biological corrosion*. US, Springer, V. 2, 1972, page 1–42.
15. Gerasymenko, A. A.: *Protection of machines, equipment and structures against corrosion, aging and biodegradation.* Handbook: [2 Vols.]. Moscow. Russia: Mechanical engineering, V. 1, 1987, page 688.
16. Bennett, W.: *Mycotoxins*, Clinical Microbiology Review, 16 (3), 2003, page 497–516.
17. Gravesen, S., Frisvad, J. C., & Samson, R. A.: *Microfungi* (No. Ed. 1). Copenhagen: Munksgaard International Publishers Ltd., 1994, page 168.
18. Pitt, J. I.: *Toxigenic fungi and mycotoxins*. British Medical Bulletin, 56 (1), 2000, page 184-192.
19. Pieckova, E., & Jesenska, Z.: *Microscopic fungi in dwellings and their health implications in humans*. Annals of Agricultural and Environmental Medicine, 6 (1), 1999, page 1-12.
20. Peraica, M., Radic, B., Lucic, A., & Pavlovic, M.: *Toxic effects of mycotoxins in humans*. Bulletin of the World Health Organization, 77(9), 1999, page 754-766.
21. Shephard, G. S.: *Impact of mycotoxins on human health in developing countries*. Food Additives and contaminants, 25(2), 2008, page 146-151.
22. Bilai, V. I., & Koval, E. Z.: *Aspergillus*. Kiev, Ukraine, 1988, page 204.
23. Domsch, K. H., Gams, W., & Anderson, T. H.: *Compendium of soil fungi*. Volume 1. Academic Press (London) Ltd., 1980, page 859.
24. Ellis, M.B.: *More Dematiaceous Hyphomycetes*. CAB Inter. Mycological Institute Kew, Surrey, England, 1989, page 507.

25. Samson, R. A., & Frisvad, J. C.: *Penicillium subgenus Penicillium: new taxonomic schemes and mycotoxins and other extrolites*, 2005.

Monika Puchlik[1)], Jakub Łozowicki[2)],
Katarzyna Ignatowicz[3)], Bożena Łozowicka[4)]
[1),2),3)]Technical University of Bialystok
Faculty of Civil and Environmental Engineering
[4)]Institute of Plant Protection - National Research Institute, Bialystok
[1)]m.puchlik@pb.edu.pl,[3)]k.ignatowicz@pb.edu.pl

Use of constructed wetlands method to remove selected pesticides from wastewater from fruit and vegetable industry

Key words: *Constructed wetland, pesticides, wastewater from fruit and vegetable industry*

Summary: Pesticides are one of many chemical contaminations of wastewater in food industry. These compounds are present in fruits and vegetables treated by technological processing and as a results get into the wastewater. Podlaskie is a typical agricultural region and the problem of the wastewater treatment affects many fruit-vegetable processing institutions. Due to the significant fluctuations in their composition, high concentrations of organic matter, ammonium and most of all low availability of organic carbon, they are difficult to purify by classical biological processes. The aim of this work is to present the possibility of applying the hydrophyte method for elimination of pesticides from fruit-vegetable wastewater samples and evaluate the effectiveness of their removal using gas chromatography technique. For experiments fungicide and insecticide were chosen which are commonly detected in chemically protected fruits and vegetables and also in wastewater from food industry. The research was carried in a pilot-scale, in sewage overgrown with reed in the autumn season of 2015. Technology of hydrophyte deposits proved to be a highly effective method of removing pesticides present in the wastewater from a small fruit-vegetable processing institution. The fungicide and insecticide removed with comparable efficiency, effectiveness for chlorpyrifos ethyl was 97% and purification effect for azoxystrobin was 93%.

1. Introduction

Knowledge about chemical contaminants present in the wastewater from fruit-vegetable industry and their effects on human health and the environment is not impressive, little known in Poland. Wastewater from industry contains nitrates and nitrites, heavy metals such as lead, copper, zinc, cadmium, chromium and nickel. Pesticides are one of many chemical contaminants of wastewater from food industry, since they are present in fruits and vegetables treated to processing technology. It is mostly related with the wide use of chemical plant protection products in agriculture in order to obtain higher yields and better quality of fruit and vegetables [1, 2]. The most commonly occurring pesticides in fruits are: dithiocarbamates, captan, difenoconazole, boscalid and alpha-cypermethrin and among insecticides: chlorpyrifos and fenazaquin [3], and in vegetables chlorpyrifos and among fungicides dithiocarbamates, azoxystrobin, strobilurin and chlorothalonil [1]. The impact of these pollutants on the human body can lead to cancer, mutagenic and genotoxic diseases, infection of the respiratory system, gastrointestinal tract, headache, and malaise, eye and skin irritation and other diseases. The most toxic are insecticides: organophosphates and pyrethroids, used to fight against pests, some fungicides and herbicides, particularly dangerous for the aquatic organisms, including fish, which tend to accumulate pesticides in their bodies. A huge variety of chemical structures, action and application of these substances makes them difficult to classify. There are several classifications based on application or mode of action or chemical and toxicological classification. Knowledge of these classifications is necessary to determine the total potential and actual risks from pesticides.

The most common classification based on the pesticide applications (Table1).

Table 1. Classification of pesticides according to their use

Group	Subgroup	Application	Group	Application
zoocides	insecticides	an insecticidal	**herbicides**	to control weeds
	acaricides	for killing mites plant	**fungicides**	to kill or inhibit fungi or fungal spores
	rodenticides	antirodents		
	moluscocides	to kill mollusks	**growth regulators**	stimulatory or inhibiting the life processes of plants
	limacides	do zwalczania ślimaków nagich		
	nematicides	nematocidal	**synergists**	to heightened action of other substances
	bactericides	bactericide		
	attractants	attracts insects or other animals.	**desiccants**	drying the leaves
	repellents	discourages insects	**defoliants**	

	aphicides	operate selectively on the aphids		to removed an excessive amount of flowers
	larvicides	operate on the larvae		

Source: [1]

Most pesticides are in several groups of compounds: esters of phosphoric acids, aliphatic and aromatic chlorinated acid derivatives, carbamates and dithiocarbamates, acid aryl alkyl derivatives, triazine derivatives, nitrophenols, urea derivatives, organic compounds of mercury, tin and copper, synthetic pyrethroids, other compounds. Within the classification of pesticide toxicology, the differentiating criterion is acute toxicity of the compounds expressed by the LD50 (ang. *lethal dose*), in milligrams of toxic substances per kilogram of the body, which after a single dose causes death of 50% of the studied of animal population. The World Health Organization (WHO) periodically publishes reports (2009), including a list of pesticides according to the proposed classification adopted worldwide (table 2).

Table 2. Classification of pesticides for toxicity according to the World Health Organization

Group		LD_{50} to rat (mg/kg)	
		oral	skin
Ia	extremely dangerous	<5	<50
Ib	very dangerous	5-50	50-200

II	a moderately damaging	50-2000	200-2000
III	a slightly dangerous	> 2000	> 2000
U	does not pose severe threat	≥ 5000	

Source: [4]

2. Fruit-vegetable processing industry

Fruit-vegetable processing industry is very widespread. Identification of the scale of the problem of the impact of food processing industries on the environment is extremely difficult. This is caused by the structure of industry in Poland, which is characterized by a high degree of fragmentation. Currently, Poland has about 2 400 institutions, more than 90% are small and 6% are large [5]. Fruit-vegetable industry generates a relatively large amount of wastewater. Annually more than two million tons of fruit and vegetables is processed [6]. In the processing of one ton of fruits and vegetables from 5 to 20 m^3 waste water is formed. The total amount of wastewaters in the country varies between 16 and 19 hm^3 depending on the year. With such a large amount of wastewater only 48% has been pre-cleaned by the sewage treatment process and the rest of the wastewater is discharged directly into water or soil. Larger institutions monitor plant material for the presence of pesticide residues, much less the level of nitrates in fruits and vegetables are controlled, small entities do not make such tests.

2.1. Methods for pesticide removal from wastewater

There are many methods of wastewater treatment with pesticides. They are based on adsorption, the adsorbents commonly used are active carbon [7,8,9,10,11], zeolite [12] or hydrogel polymers [13], natural products and waste and by-products from industry, *eg.*: straw [14], lignin [15], the shell chestnuts [16], husks of wheat [17], watermelon rind [18], soybeans and ash [19], pine bark, sugar cane, coconut, bauxite, sawdust and rice bran [20].The oxidation reactions, the catalysts in the photolysis are *e.g.* zinc oxide [21], titanium oxide [22], ozone [23] and hydrogen peroxide [23,24]. In sonic treatment ultrasound waves having a high frequency are used [25,26]. Oxidation of organic compounds in wastewater can also be held during the cavitation process [27], using microwave pulses [28] or a modified electrode in the electrocatalysis [29] or electrocoagulation[30]. The literature describes a membrane filtration techniques [31,32] and coagulation using calcium [33]. Among biological methods can be distinguished activated sludge and hydrobotanical wastewater treatment by the use of certain plant species characterized by a high capacity to bioremediation. For over twenty years, popularity of hydrophytes sewages involving plants increased. High purification effect is achieved at low investment for construction and exploitation, and plants inhabiting ledges charge nitrogen and phosphorus compounds. Most scientific papers on the effectiveness of wastewater treatment in the soil-plant systems, are focused mainly on the problems of removal of total suspended solids, organic substances (BZT_5 and ChZT) and biogenic elements (nitrogen and phosphorus). There are few specialist reports regarding the effectiveness of the pesticide removal and concern of individual pesticides. Due to significant variations in the composition of the wastewater, high concentrations of organic substances, ammonia nitrogen, and above all the low availability of organic carbon, pesticides are difficult to purify by application of the classical biological processes. The aim of this study is to present the possibility of applying the hydrophyte method for wastewater treatment from the fruit-vegetable industry containing pesticides.

3. Material and methods

The experiment was performed in a fluid bed with a vertical flow - VF, a length of 0.7 m and a width of 0.7 m and a depth of 0.8 m, a surface 0,5 m^2. It has three layers of filling, starting from the top: I layer - sand (d_{10} = 0.1 - 2 mm, 0.15 m), the second layer - gravel (d_{10} = 2 - 8 mm; 0.50 m), the third layer - stones (d_{10} = 20 - 80 mm, 0.15 m), which was mounted on common reed (*Phragmites australis*) (Figure 1). To evaluate the effectiveness of the removal of pesticides, wastewater samples from a small fruit-vegetable industry were used.

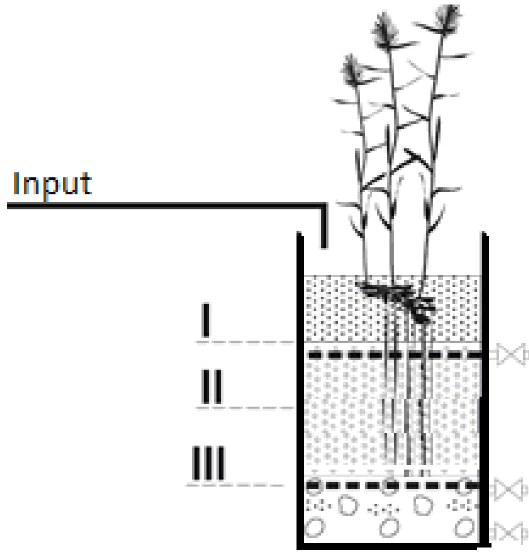


Figure 1. Constructed wetland with vertical flow
Source: [34]

Six experimental series were performed in the autumn of 2015. The collected samples of raw and cleaned wastewater were determined:

- pH - potentiometric method,
- biological oxygen demand BOD_5 [mg O_2 / l] - by manometric,
- chemical oxygen demand COD [mg O_2 / l]- dichromate method,
- ammonium nitrogen [mg $N\text{-}NH_4^+$ / l] - spectrophotometric method,
- nitrates V [mg $N\text{-}NO_3$ / l] - spectrophotometric method,
- total nitrogen [N mg / l] - spectrophotometric method,
- total phosphorus [P mg / l] - spectrophotometric method,
- phosphates [mg $P\text{-}PO_4$ / l] - spectrophotometric method.

Additionally, in selected samples pesticide concentrations were determined [mg/l] by gas chromatography equipped with dual detection system: electron capture and nitrogen - phosphorus (ECD / NPD) in Plant Protection Institute - National Research Institute using Agilent 6890. The pesticide standards were purchased from Dr. Ehrenstorfer Laboratory

(Augsburg, Germany) with purities 99.8%. Acetate ethyl, issoctane, hexane and acetone were purchased from Merck (Darmstadt, Germany). Sodium chloride was purchased from Agilent Technologies (Santa Clara, USA). The working standard solutions were used for the preparation of matrix-matched standards within the concentration range of 0.1 μg ml^{-1}. A sample of 250 ml wastewater was extracted twice using two portion of 75 ml acetate ethyl. The organic layers were combined and anhydrous Na_2SO_4 was added and decanted. The extract was evaporated to dryness using a rotary vacuum evaporator at a temperature of about 40 °C. Then the eluate was re-dissolved using 2 ml of hexane/acetone (9:1, v/v). The wastewater samples were analyzed by an Agilent (Waldbronn, Germany) model 7890A gas chromatograph equipped with ECD and NPD detectors. A capillary column HP-5 (5 %-phenylmethylpolysiloxane) (30 m × 0.32 mm, 0.5 μm film thickness) and for confirmation of residues a mid-polarity column HP-35 (35 %-Phenyl)-methylpolysiloxane (30 m × 0.32 mm, 0.5 μm film thickness) were used. The injector and detectors temperature were set at 210 and 300 °C, respectively. The oven temperature was programmed as follows: 120 to 190 °C at a rate of 16 °C min^{-1}, increased to 230 °C at 8 °C min^{-1} and then to 285 °C at 18 °C min^{-1}, and remain there for 18 min. Helium (purity 5.0) was used as a carrier gas at a flow rate of 3.0 ml min^{-1}. Nitrogen (purity 5.0) was used as a makeup gas: EC detector and NP detector were set at 57 and 8 ml min^{-1}, respectively. The air (purity 5.0) and hydrogen (purity 5.0) (for NPD) gas flows were set at 60 and 3 ml min^{-1}, respectively. A 2 ml of the extracted sample solution was injected.

4. Results and discussion

Table 3 shows the minimum and maximum values of the characteristic parameters of contamination of raw wastewater applied to the ledge and wastewater cleaned on hydrophyte ledge. Figure 2 shows the average temperature recorded in October and November.

Table 3. Qualitative characteristics of sewage samples from the experimental treatment (minimum and maximum values) collected from October to November 2015

Indicator / Unit			Raw wastewater	Treated wastewater
pH		min.	4,5	6,3
		max.	11	7,3
BZT_5	mg O_2/l	min.	650	105
		max.	2600	240
ChZT-Cr	mg O_2/l	min.	2500	175
		max.	6577	525
Ammonium nitrogen	mg N-NH_4/l	min.	19,6	1
		max.	56	6,4
Nitrates V	mg N-NO_3/l	min.	1,3	0,6
		max.	7,9	1
Total nitrogen	mg N/l	min.	28	18
		max.	74	25
Total phosphorus	mg P/l	min.	0,6	0,5
		max.	8,9	0,6
Phosphates	mg P-PO_4/l	min.	0,5	0,4
		max.	8,9	0,6

Source Own elaborated

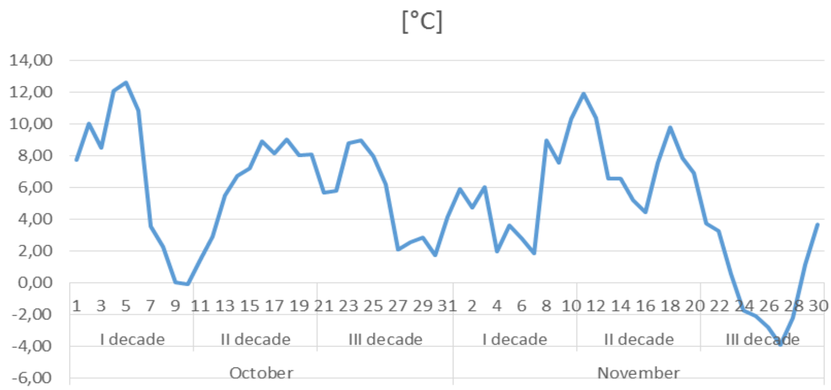


Figure 2. Temperatures in October and November 2015., Bialystok

Source: Own elaborated

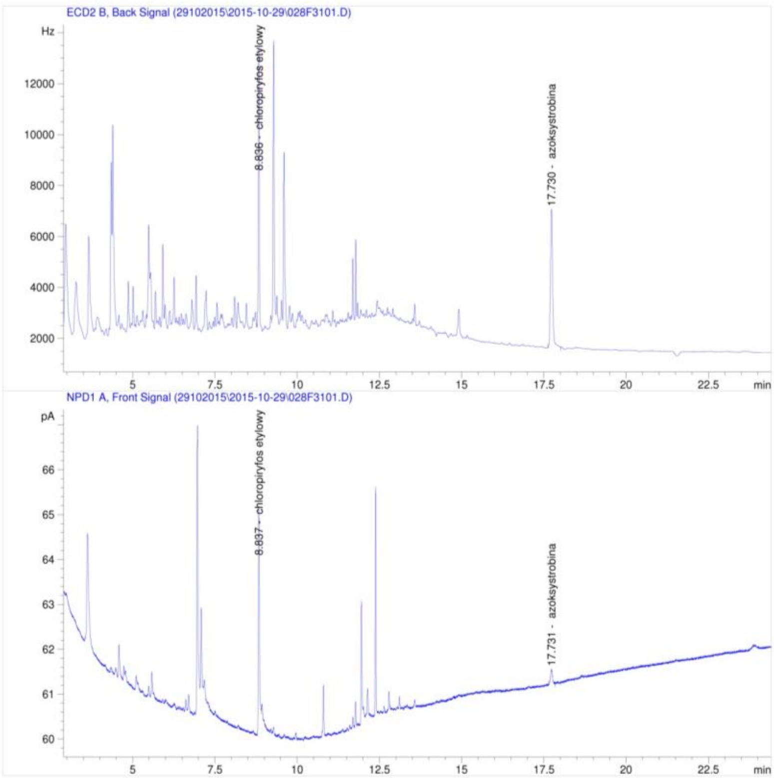


Figure 3. The chromatogram of azoxystrobin and chlorpyrifos of ethyl identified in a sample raw wastewater

Source: Owm elaborated

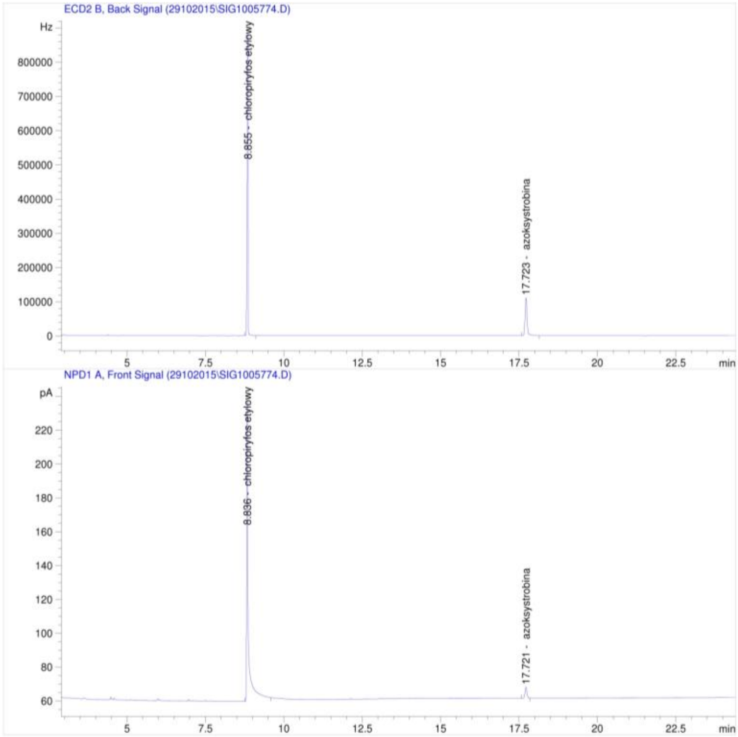


Figure 4. The chromatogram of azoxystrobin and chlorpyrifos of ethyl identified in a sample treated wastewater, Series I

Source: Own elaborated

Table 4 and Figures 3-4 show the value of marked two concentrations of pesticides in raw wastewater and treated wastewater.

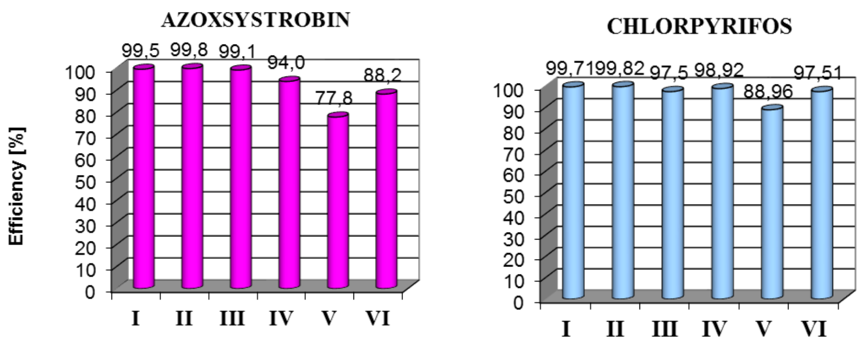
Table 4. The mean concentrations pesticides in treated wastewater and treated for bed I (experiment conducted 1 October 2015, E 1)

Pesticide	Concentration [min-max]	
	Raw wastewater	Treated wastewater
Azoxystrobin	0,3104-0,556	0,0007-0,0336
Chlorpyrifos	0,0674-0,1879	0,0001-0,0074

Source : Own elaborated

Analysis of the results confirms the average variability of quality in time for the raw and cleaned wastewater. The maximum values of contamination concentrations were several times higher than their initial values. Raw wastewaters leaded to ledge characterized by a great diversity of pH from acid to base. In the purified wastewater this parameter ranged in the pH slightly acidic and neutral (table 3). Analyzing the removal efficiency of organic matter in the wastewater very high decrease of BZT_5 and ChZT values was found. The five-day biochemical oxygen demand of the raw wastewater ranged from 650 to 2600 mg O_2/l, and after cleaning decreases to 545 mg O_2/l and 2360 mg O_2/l. In the case of the ChZT parameter, the initial values ranged from 2500 to 6577 mg O_2/l and after treatment were reduced 12 - 14 times. This applies not only to BZT_5 i ChZT, but also concentration of ammonia nitrogen. Its value decreased after cleaning 8-20 times. The minimum value of the ratio of BZT_5/ChZT for raw wastewater was 0.25 and the maximum 0.39. A slightly higher values of the ratio were obtained for cleaned wastewater 0.6 and 0.46. Low values of the ratio of BZT_5/ChZT and a significant reduction of the ChZT concentration in the samples after filtration indicated that the analyzed wastewater organic matter was present primarily in the form of hard degradable suspension. From the sewage industry point of view, very important is concentration of nitrogen and phosphorus. Total nitrogen and nitrogen in the nitrate form was reduced. The overall concentration of nitrogen decreased 5 - 3 times, and in the form of nitrates 2 - 8 times. There were significant decrease in the levels of total phosphorus and phosphates in wastewater subjected to purification on the hydrophyte ledge (Table 3). Literature data confirm that this is possible in installations during the start-up and initial operations. The efficiency of wastewater cleaning in the case of ammonium nitrogen was very high, which resulted from a significant increase in the concentration of nitrogen in raw wastewater. According to research by Warężak et al. [35] removal efficiency of organic pollutants, hydrophyte sewage in Przyborowo after 16 years of working, during this period was high and for BZT_5 ranged from 88 to 97%, and ChZT from 85 to 97%. In the experimental sewage nitrification process was noted, evidenced by 88 to 95% reduction of the ammonia nitrogen concentration. Total nitrogen was removed from the wastewater with efficiency from 36 to 66%. The phosphorus compounds were removed in the late autumn and were at approximately level of 53% phosphates and phosphorus in the range of 10 - 93% (Table 3). Research conducted by Magrel [36] on two objects in Podlaskie showed the removal of phosphorus in the range from 11.6% to 41.9%. Comparing the removal efficiency of the fungicide azoxystrobin (Figure 5), high efficiencies were obtained in the first four series (98.1%). In the last two series we have seen a marked decline in the efficiency of azoxystrobin removal. The fifth run resulted in 77.8% and sixth in 88.2% yield. The average yield of the removing process of this fungicide throughout the study period for six series was 93.1%.

Figure 5. Efficiency of removal of azoxystrobin and chlorpyrifos from wastewater fruit and vegetable



Source: Own elaborated

A similar trend was observed in the second pesticide chlorpyrifos, but the efficiency of its removal was higher than azoxystrobin (Figure 5). Very high efficiency was achieved in the first four series (99%). In the last two series we have seen a marked decline in the efficiency of insecticide removal. The fifth run resulted in 89% and sixth 97.5% yield. The average yield of removing process of this insecticide throughout the study period for six series was 97%. The effectiveness of wastewater cleaning methods from pesticides depended on many factors: the time of treatment, pH treatment, temperature and time of year, the initial concentration of pesticides, pesticide type, the quantity of used catalysts, adsorbents or electrolyte solutions (Table 4, Figure 3.4). In the present study, the reduction of pesticide removal efficiency in the last two series may be explained by weather conditions. Samples for the fifth and sixth series were taken in late autumn, when the temperature decreased significantly in this period (Figure 2).

In the literature are often described the results of the pesticideremoval such as atrazine, chlorpyrifos, malathion, simazine, diazinon, imidacloprid, methyl parathion and organochlorine pesticides (including heptahlor, HCH). A review of the literature shows that the chlorpyrifos removal from aqueous solutions, method combining the microwave radiation with UV-radiation and the use of TiO_2 and H_2O_2 is preferred, which gives a very high efficiency. Diazinon is removed nearly in 100% from wastewater using a photocatalytic Fenton reaction in combination with adsorption on activated carbon. Electrocoagulation is a very good method for wastewater treatment with malathion and imidacloprid. Removability of pesticides for this technique is 98 - 99%.

Organochlorine pesticides and atrazine are removed in 98% on biological sewage cleaning using activated sludge.

This study of the application of hydrophyte ledge in a pilot-scale of fruit-vegetable wastewater cleaning of azoxystrobin and chlorpyrifos, yielded in very promising results, and removability of pesticides for this technique was 78 - 99%. The taken topic is very interesting and in a very narrow extent hydrophyte method of ledges is described in the literature. There were no papers for pesticide removal from fruit-vegetable wastewater. Conducted research requires a deeper analysis in the future to evaluate the effectiveness and impact of a number of parameters. This experiment should be continued and extended with further studies of pesticides, commonly found in sewage fruit and vegetables.

5. Conclusions

On the basis of the research analysis we found:

1. Technology of hydrophyte ledges is a highly effective method for pesticide removal.
2. Fungicide and insecticide removed from the fruit-vegetable wastewater with comparable efficiency.
3. The purification efficiency of chlorpyrifos was 97% and the effect of the azoxystrobin elimination reached 93%.
4. The sand ledge with vertical flow, overgrown with reeds, proved to be very effective in the treatment of wastewater from a small fruit-vegetable industry.
5. Gas chromatography technique in the dual detection system is an excellent method for monitoring the presence of pesticides in complex matrices.

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References:

1. Łozowicka B.: *Studium nad pozostałościami środków ochrony roślin w płodach rolnych północno-wschodniej Polski.,* Vol. 20, Wyd. IOR PIB, Poznań, 2010.
2. Skoczko I.: *Próby zastosowania węgla pylistego do unieszkodliwiania pestycydów w ściekach*. Środkowo-Pomorskie Towarzystwo Naukowe Ochrony Środowiska, Vol. 11, 2009.
3. Łozowicka B., Hrynko I., Kaczyński P., Rutkowska E., Jankowska M., Mojsak P.: *Occurrence of pesticide residues in fruit from Podlasie (Poland) in 2012*. Journal Plant Protection Research, Vol. 2, 2012, page 142–150.
4. WHO: *The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification: 2009*. http://www.inchem.org/documents/pds/pdsother/class_2009.pdf [dostęp: 11.12.2015].
5. Główny Urząd Statystyczny, Podmioty gospodarki narodowej zarejestrowane w rejestrze REGON, deklarujące prowadzenie działalności, według szczególnych form prawnych oraz PKD200, Kwartalna informacja o podmiotach gospodarki narodowej w rejestrze REGON deklarujących prowadzenie działalności, 2015.
6. Analizy rynkowe. Rynek owoców i warzyw. Wyd. IERiGŻ, Warszawa, 2014, page 44

7. Choma J., Jaroniec M., Burakiewicz-Mortka W., Gwizdalski M.: *Adsorpcja związków organicznych na węglach aktywnych*. Ochrona Środowiska, Vol. 1, No 56, 1995, page 34–40.
8. Gupta V.K., Gupta B, Rastogi A, i Agarwal S, Nabak A.: *Pesticides removal from waste water by activated carbon prepared from waste rubber tire*, Water Research, Vol. 45, 2011, page 4047–4055.
9. Hassan A. M., Abed El-Moteleb M. and Ismael M A.: *Removal of lindane and malathion from wastewater by activated carbon prepared from apricot stone*. Assiut University Bulletin For Environmental, Vol. 12, No 2, 2009, page 56–62.
10. Ninković M. B., Petrović R. D., Laušević M. D.: *Removal of organochlorine pesticides from water using virgin and regenerated granular activated carbon*. Journal of the Serbian Chemical Society, Vol. 75, No 4, 2010, page 565–573.
11. Taborska M., Falkowski Ł.: *Zastosowanie węgli aktywnych w procesie oczyszczania ścieków z produkcji pestycydów w zakładach chemicznych „Organika-Azot" S.A. w Jaworznie. Węgiel aktywny w ochronie środowiska i przemyśle*, 2006, page 15-18
12. Valičkova M., Derco J., Šimovičova K.: *Removal of selected pesticides by adsorption*, Acta Chimica Slovaca, Vol. 6, No 1, 2013, page 25–28.
13. Tiwari A., Bind A., Effective removal of pesticide (Dichlorvos) by adsorption onto super paramagnetic poly (styrene-co-acrylic acid) hydrogel from water. International Research Journal of Environmental Sciences,2014, Vol. 3, No 11, 41–46.
14. Sukru A., Aysen T.: *Simultaneous biological removal of endosulfan (a+h) and nitrates from drinking waters using wheat straw as substrate*. Environment International, Vol. 30, 2004, page 449– 455.

15. Ludvık J., Zuman P.: *Adsorption of 1,2,4-triazine pesticides metamitron and metribuzin on lignin*, Microchemical Journal, Vol. 64, 2000, page 15–20,
16. Zuhra G., Bhanger M.I, Akhtar M.: *The removal efficiency of chestnut shells for selected pesticides from aqueous solutions*. Journal of Colloid and Interface Science, Vol 315, 2007, page 33–40.
17. Gupta K., Jain R., Varshney S.: *Removal of Reactofix golden yellow 3 RFN from aqueous solution using wheat husk - An agricultural waste*. Journal of Hazardous Materials, Vol. 142, 2007, page 443–448.
18. Zuhra Memon G., Bhanger M.I., Akhtar M., Farah N. Talpur, Jamil R. Memon.: *Adsorption of methyl parathion pesticide from water using watermelon peels as a low cost adsorbent*. Chemical Engineering Journal, Vol. 138, 2008, page 616–621.
19. Mittal A., Kaur D., Mittal J.: *Applicability of waste materials - bottom ash and deoiled soya - as adsorbents for the removal and recovery of a hazardous dye, brilliant green*, Journal of Colloid and Interface Science, Vol. 326, 2008, page 8–17.
20. Srivastava B., Jhelum V., Basu P., Patanjali K.: *Adsorbents for pesticide uptake from contaminated water: A review*, Journal of Scientific and Industrial Research, Vol. 68, 2009, page 839–850.
21. Daneshvar N., Aber S., Seyed Dorraji M.S., Khataee A.R., Rasoulifard M.H.: *Photocatalytic degradation of the insecticide diazinon in the presence of prepared nanocrystalline ZnO powders under irradiation of UV-C light*, Separation and Purification Technology, Vol. 58, 2007, page 91–98.

22. Rajeswari R., Kanmani S.: *A study on degradation of pesticide wastewater by TIO_2 photocatalysis*, Journal of Scientific and Industrial Research, 68, 2009, page 1063-1067.
23. Parag R., Aniruddha B.: *A review of imperative technologies for wastewater treatment I: oxidation technologies at ambient conditions*, Advances in Environmental Research, Vol. 8, 2004, page 501–551.
24. Alalm M., Tawfik A., Ookawara S.: *Comparison of solar TiO_2 photocatalysis and solar photo-Fenton fortreatment of pesticides industry wastewater: Operational conditions, kinetics, and costs.* Journal of Water Process Engineering, Vol. 8, 2015, page 55–63.
25. Matouq A., Zaid Al-Anber A., Tagawa T., Aljbour S., Al-Shannag M.: *Degradation of dissolved diazinon pesticide in water using the high frequency of ultrasound wave,* Ultrasonics Sonochemistry, Vol. 15, 2008, page 869–874.
26. Dehghani M., Fadaei A.: *Sonodegradation of organophosphorus pesticides in water*. Environment Protection Engineering, Vol. 39, No 4, 2013, page 123–129.
27. Rajendrasinh R., Reshma G., Patel L.: *Pesticide wastewater treatment by hydrodynamic cavitation process.* International Journal of Advance Research in Engineering, Vol. 2, No 5, 2015, page 3045–3051.
28. Barros F., Barros L., Silva A., Nascimento F.: *Use of Microwave-Assisted Oxidation for Removal of the Pesticide Chlorpyrifos from Aqueous Media*. International Journal of Civil & Environmental Engineering, Vol. 13, No 6, 2013, page 16–27.

29. Garrett P.: *Electrochemical degradation of some pesticides in agricultural wastewater by using modified electrode*, International Journal of Agricultar & Environmental, Vol. 1, 2013, page 53–61.
30. Abdel-Gawad S., Baraka A., Omran K., Mokhtar M.: *Removal of Some Pesticides from the Simulated Waste Water by Electrocoagulation Method Using Iron Electrodes.* International Journal of Electrochemical Science, Vol. 7, 2012, page 6654–6665.
31. Yoshiaki K., Yuta N., Takane K., Kazuyuki N.: *Rejection properties of non-phenylic pesticides with nanofiltration membranes,* Journal of Membrane Science, Vol. 171, 2000, page 229–237.
32. Yoshiaki K., Yosuke S., Takane K., Kazuyuki N.: *Effects of hydrophobicity and molecular size on rejection of aromatic pesticides with nanofiltration membranes*, Journal of Membrane Science, Vol. 192, 2001, page 1–10.
33. Skoczko I.: *Próby usuwania wybranego środka ochrony roślin ze ścieków metodą koagulacji wapnem*. Inżynieria Ekologiczna, Vol. 24, 2011.
34. Dąbrowski W., Wiater J., Boruszko D.: *Oczyszczanie odcieków z beztlenowej stabilizacji osadów z oczyszczalni ścieków mleczarskich przy zastosowaniu metody hydrofitowej,* Rocznik Ochrony Środowiska, Vol. 17, 2015, page 1506-1521.
35. Warężak T., Sadecka Z., Myszograj S., Suchowska-Kisielewicz M.: *Skuteczność oczyszczania ścieków w oczyszczalni hydrofitowej typu VF-CW*. Środkowo - Pomorskie Towarzystwo Naukowe Ochrony Środowiska, Vol. 15., 2013, page 25-32.
36. Magrel L.: *Oczyszczalnie hydrofitowe w gminie Sokoły, woj. Podlaskie*, Maszynopis, 2009.

Anna Kononiuk, Ph.D. Nelia Rusina
Rivne State Technical University
Soborna Street 11, Rivne 33000, Ukraine

Ways to improve soil on the example of Ukraine Khmelnitsky region

Keywords: *Ukraine, soil*

1. Introduction

Ukraine - the second largest country in Europe after Russia, and largest country, whose territory lies entirely in Europe. Historically and geographically happened so that Ukraine is rich in flora and fertile land.

In this paper describe the most soils. Ukraine has one third of the world's most productive land - black. Due to this and the easy, mostly flat terrain, more than 60% of the area of our country is occupied by agricultural land However, apart from the black soil, there are also some other types of soils. An important feature is their soil fertility. Thanks to the soil is the main means of production in agriculture and forestry, the main source of agricultural products and other plant resources, the foundation of welfare.
But now there is the problem of reducing soil fertility in Ukraine. In recent years per hectare of arable land is paid much less organic and mineral fertilizers than required (15-20 times less fertilizer than necessary). As a result, decreased humus content. Thus there is soil contamination (20% of lands) - it hit the ground various chemicals, toxins, waste products of agriculture and industrial production, municipal enterprises in amounts that exceed their normal amount required to participate in the biological cycle soil ecosystems. Significant impact on land subject to erosion - about 57.5% of the country's land.

Thus soil protection, sustainable use, conservation and improvement of soil fertility - a necessary condition for further economic progress.

Purpose - analysis of the current state of land Khmelnitsky region, identifying the main negative processes and form the necessary recommendations to improve the soil.

2. Khmelnitsky Region

Khmelnitsky region as an administrative and territorial unit of Ukraine was established on September 22, 1937. Located on the North-West of Ukraine within the Western Polissya region. The area is 20.6 thousand km^2 (3, 4 % of the territory of Ukraine). Population – 1 303 776 persons (1 October 2014). The regional center – the city of Khmelnitsky [2].

The region's territory lies between 48 ° 27 'and 50 ° 37' north latitude and between 26 ° 09 'and 27 ° 56' east longitude. The length of the region from north to south and 220 km and from west to east - 120 km. Bordered on the north-west, Rivne and Zhitomir north-east, east Vinnitsa, south of Chernovtsy, in the west of the Ternopol region [2].

Figure 1. Khmelnitsky region

Source: Own elaborated

Prominent among industries in the region covers engineering and metalworking, which employs 44.2% of workers in the industrial area. Enterprises of the industry producing machines, forging machines, transformers, agricultural machinery for crop production equipment for processing industries of agriculture, cable, electrical products [2].

The Khmelnytsky oblast is almost 4% of all agricultural land in Ukraine. Championship among sectors of agriculture holds crop. The largest areas sown in crops occupy, among them - winter wheat. Also cultivated barley, peas, oats, buckwheat, corn and others.

Khmelnytsky - one of the most important regions of cultivation of sugar beet. An important sector is the growing crop of potatoes. Production aromatic crops in Letychivsky, Derazhniansky, Khmelnytsky districts, and chicory in Slavutsky and Starokostiantynivsky areas.

Natural conditions are favorable for the development of vegetable, but the sown area of vegetables is small. More than 40% of the acreage occupied by forage crops (grasses, corn for silage, peas, vetch, fodder beet, alfalfa, canola).

Podillia is a land of gardening. Main fruits: apple, pear, apricot, cherry, walnut. The largest concentration of gardens in - Transnistria (Vinkovetsky, Dunaevsk, Novoushitskiy, Kamenets areas).

Livestock in the field based on forage production, natural pastures, waste food and animal feed major manufacturing industries are meat and dairy cattle and pigs. Developed as poultry, sheep, rabbits, beekeeping and fishing. In the program developed by the intensification of livestock industry, which is based on the establishment of specialized arrays of breeding stock, competitive dairy and beef cattle, increasing the share of hybrid and young pigs. There is a network of breeding plants and breeding farms. It is supposed to change the structure of the herd towards increase in beef cows in the Polissya zone and the reduction of dairy herds to compensate for increased productivity.

Khmelnitsky region has a well developed transport network. Equally important is its position on the transportation routes linking the main industrial regions of Ukraine (the capital. Kharkov, Dnieper, Donbas) and Russia and the Black Sea ports of western Ukraine and countries of Central and Eastern Europe.

From north to south railway and a number of roads that give out Belarus and the Baltic countries, Moldova and the countries of Southeast Europe.

Climate is temperate continental with mild winters (average January temperature is -5 ° C) and warm, humid (average July temperature is +19 ° C) in summer. Rainfall, 70% of which falls on the warm period is 500-640 mm. The surface area is gently undulating loess plains. In the north of the region is plain Woodland (with heights up to 240 m) in the north-west - Volyn, in the center - Dnieper (380 m) and the south - Podolsk (400 m) hill. In the upper reaches of the river are Goryn, Sluch and Southern Bug, define the natural shape of the areas of Polissya and Podillia. But the most beautiful and deeply incised valleys intricately Dniester and its left tributaries (Zbruch, Zhvanchyka, Smotrich, Ternava, Ushytsya et al.), sometimes form spectacular canyons and breathtaking scenery.

Most central part of the area is the Podolsk height (preferred height of 270-370 m), which forms the watershed of the Dnieper, Dniester and Southern Bug. In the northwest to the boundary comes Volyn Upland (elevations to 329 m) in the north - Woodland lowland (200-250 m altitude).

Southwest Tovtry crosses the ridge, which is the highest point of the region – Big Mountain Buhayiha (400.6 m). There are karst landforms caves are found (Atlantis, Zaluchanska).

Figure 2. Panorama of Dniester River

Source: Own elaborated

The extreme south has lock similar surface dissected canyon valleys of the tributaries of the Dniester. Dniester reservoir level (121 m) is the lowest elevation. Territory of the region flow 120 rivers longer than 10 km. The largest rivers are the Dniester river (length in the region of 160 km) with its tributaries the Zbruch, Smotrich, Ushytsya; South bug river (the length within the area 120 km) with its tributaries Buzhok, Wolf, Ikva river of the Dnieper basin — Goryn, Sluch, Khomora.

Lakes are few. Found mainly in the basin of the Goryn. You need to select the largest of the area lakes such as Blue Lake that formed in the place of waste peat quarries. The Holy Lake is the largest lake in the Khmelnitsky region. It belongs to a group Zaslavsky lakes located on the territory Myhelskoho Forestry Enterprise "Izyaslav forestry" for Small Polissya.

Figure 3. Holy Lake

Source: Own elaborated

Blue Lake located in the Belgorod region, between the villages of Zhyzhnykivtsi and Synyutka. Prince of the lake, which lies on the banks of the Goryn in Slavuta district, between the villages of Krupets and Kolom'ye.The. The largest reservoir - Dniester. Erected 1858 ponds and reservoirs, mainly in the basins of the Goryn and Southern Bug, including Schedrivske (1258 ha), Novostavske (1168 ha), Kuzminska (765 hectares).

In the region there are more than 3 thousand rivers and streams. The largest rivers are the Dniester, South bug, Goryn, Sluch, Zbruch, Smotrich and Homora. The region has 60 reservoirs with a volume of 153 million cubic meters of water, 1799 ponds. The largest reservoir - Schedrivske Dniester and the Southern Bug. For stocks Water region ranked 6th in the country.

Khmelnytsky region rich in a variety of non-metallic minerals, primarily natural building materials. It is promoted as a shield crystalline rocks and sedimentary deposits its western slope. At the same time it is completely devoid of metal mineral resources, but from fossil is an only deposit of peat.

3. Soils Khmelnitsky

The largest area of Khmelnitsky region is forest-steppe ashed soils, which unite in subtypes:

Light gray and gray forest - common at heights and slopes in different districts, but most particularly in its South-Western and Southern parts. They were formed on loess and loess-like loam under forest vegetation. The humus horizon has a small thickness, the humus content is low (1,5-2,2%). Clearly detected whitish eluvial horizon (10-15 cm), enriched kremyankoyu. The wide ashes show a pronounced deep illuvial horizon. It is very dense, walnut-prismatic structures enriched in colloids, waterproof. The influx of colloids through fractures he very gradually goes to a depth of 130-140 cm in the parent rock, what is here is mostly loess carbonate loam. Structureless soils are acidic, low nutrient content and therefore require liming, fertilization. Dark gray ashed - occupy areas aligned gentle slopes and watersheds in the central and southern parts of the region. They ashed less than the previous soils are deeper humus layer (55-65 cm), the top of which contains up to 2.9-3.1% humus. These soils have a better structure, significant nutrient content and therefore extensively used in agriculture.

Figure 4. Light gray and gray forest

Source: Own elaborated

The reaction of soil solution slightly acidic (pH 5.8), low hydrolytic acidity - 2.4 mEq per 100 g soil, the degree of saturation basics reaches 75-90%. They are well equipped with accessible forms of plant nutrients (nitrogen from 4.3 to 10.2; phosphorus is 2.8-14.6; potassium from 4 to 15 mEq per 100 g of soil). The properties and fertility of dark gray soils like ashed and therefore all measures for reclamation and cultivation, and cultivation of crops they are identical.

Black ashed are located in the Central and southern parts of the region. They are formed on the leveled plateau near forest and steppe vegetation, have a deep humus layer (80-90 cm) humus content in the upper horizon - 3,0-4,0%. Due to their extensive use, gradually deteriorate the properties of these soils, first of all, the structure and water-air regime. To increase crop yields necessary to make organic and mineral fertilizers, proper organization of crop rotation and others.

Chernozem typical extended to low and flat watershed ridges and their gentle slopes in central and terraces above the floodplain rivers Volyn Upland. They were formed under meadow steppes in conditions mild and humid climate. This option extreme western steppe black soil, which are some of its features. They are poorly structured little humus (2-3%). For deep humus color they are divided into medium deep (70-100 cm) and deep (100-150 cm). In mechanical composition is light or coarse silt loam. The content of coarse dust in them is 54-65%. The reaction of soil solution typical black soil slightly acid, pH fluctuates within 5.9-6.6. They are well saturated with calcium to absorb (12.2-27.9 mg-EQ per 100 g of soil).

The line of effervescence from hydrochloric acid lies at a depth of 40-50 cm. less common leaching and carbonate soils. Calcium carbonate out in the transitional horizon and parent material in a mold and white stars. Better than any other region soils, they are equipped with mobile forms of nutrients.

Figure 5. Chernozem typical

Source: Own elaborated

4. Soil degradation

The most common problem is - reduction of soil fertility. One of the most important components of soil is humus. Over the past 20 years the average content Ukraine decreased by 0.22% in absolute terms. This is too much so as to increase the humus in the soil by 0.1% in the wild should be 25-30 years [9].

The main causes of soil degradation [10]:

- multiple cultivation with powerful, heavy wheel tractors and harvesters;
- insufficient amounts of organic fertilizers (average for 2009-2014 of Ukraine made manure less than 1 ton per hectare, while the minimum standard to ensure a balanced balance of humus, depending on soil and climatic zones, ranging from 8 to 14 tons per hectare);

- water and wind erosion of soil;
- breach rotation (for example, this depletes the soil as sunflower culture in some regions of Ukraine occupies over 30% of arable land. In the Ukrainian realities culture right back to the previous 3 years, and recommended - 6-7 years);
- looding of land (approximately 12%), acidification (almost 18%), salinity and alkalinity of soils (over 6%);
- use of high doses of mineral fertilizers and crop protection chemicals.

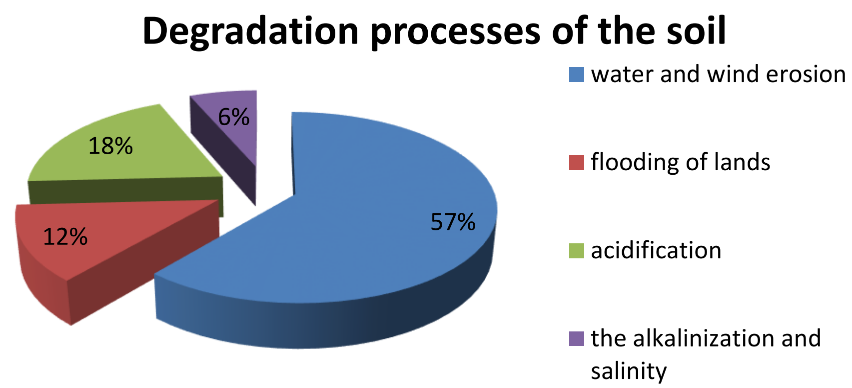


Figure 6. Chart of the degradation processes of the soil

Source: [10]

Especially dangerous extent of soil erosion has become - the most common process of destruction of soil. To produce 1 ton of crop production (in the conventional grain) erosion lost about 7 tons of soil (Table 1). Total annual losses from erosion are around the country at 3.45 billion USD, and losses net profit of 2 billion UAH.

Eroded lands have a worse than full profile, physical, physic mechanical, agrochemical and biological properties, so that they the shortfall much of the crop. With each flushing cm humus horizon potential grain yield is reduced by 0.5-2 kg / ha, but with the loss of 1 ton of useful energy reserves of humus in the soil reduced by 0,9-1,1 kJ / ha.

Table 1. Crop yields dependence on the degree eroded of land to not eroded, %

Culture	Steppe			Forest steppe		
	Weakly eroded	Some eroded	Strongly eroded	Weakly eroded	Some eroded	Strongly eroded
Winter wheat	90	74	62	86	63	44
Winter rye	98	85	-	93	85	57
Spring barley	85	64	50	81	57	51
Oat	79	58	45	79	63	50
Pea	92	86	55	85	6	51
maize	82	60	44	77	9	27
Sugar beet	81	62	-	79	53	49
Sunflower	78	58	-	-	-	-
Sainfoin	89	85	83	-	84	77
Alfalfa	92	84	78	-	83	79

Source: [8]

Very dangerous problem is the contamination of soil. Most soil contaminated by metal compounds and organic substances, oils, tar, pesticides, explosives and toxic substances, radioactive, biologically active combustible materials, asbestos and other harmful products. The source of most pollutants are industrial or household waste disposed in certain places, or unauthorized landfills.

Serious soil contamination problem is man-made emissions of industrial enterprises. In solid and liquid industrial waste are constantly present substances that can have a toxic effect on living organisms and plants. For example, waste steel industry typically present ferrous salts of heavy metals.

According to scientists today more than 9.0 million. Ha of agricultural lands contaminated due to the Chernobyl disaster, large areas of soil contaminated by pesticides every year and about 20% of arable land polluted with heavy metals [3].

Details analyzing the reasons for the decline of soil fertility Khmelnitsky region, including the particular attention paid to water and wind erosion of soil, soil contamination by heavy metals, radionuclide, pesticides and so on. The following measures for possible reproduction and preservation of soil fertility in modern conditions. Basic principles of rational use and protection of land resources, as reflected in the Law of Ukraine "On Land Protection" of 19 June 2003. This Act clearly stipulates that the land owners and land users, land rights entities required to effectively use the land for the purpose, use environmental technology production, improve soil fertility and prevent environmental degradation in the territory as a result of production and business activities.

For efficient agricultural production, rational use and protection of lands, creation of favorable ecological environment and improvement of natural landscapes developed land management projects that provide a set of anti-erosion measures. Erosion organization of the territory is carried out in sequence:

- the distribution of funds for land use intensity;
- Placing water-regulating strips reinforced ditch and rampart road to move within one fund to another;
- Organization of crop rotation on selected funds.

The basis of the contour of the territory is differentiated use of land depending on its soil and landscape conditions and the ability of soil crops. When designing or conducting group differentiation depending on the type of land use. Correct placement of design elements requires that you calculate the placement of gully systems, the terrain, the soil and the degree of their erosion, and when wind erosion degree – placement dropdown slopes, areas of light grants the wind direction.

Plant capacity of soil depends on the mass of roots in the soil. Conventionally, plants can be divided into 3 groups:

1) resistant to washing and blowing wind - grasses;
2) unstable - crops and annual grasses;
3) unstable - row crops and pure steam. Differentiated use of arable land in farms provides for a system of crop rotation. To protect the soil from erosion using erosion following measures: organizational, economic, land improvement, agro forestry and Irrigation and drainage [1].

Organizational and economic measures include the creation of conditions for the prevention and suppression of erosion, management of land and improve soil fertility. Activities of the group include [6]:

- the right choice towards agriculture and crop rotation, rational distribution of soil crop rotation;
- rational distribution and construction of the road network;
- proper planning of the village and lands that surround them;
- placement of fields along the long side contour area.

Land improvement erosion control measures are technology-erosion techniques of cultivation on slopes. These include:

- phytomeliorative agronomic techniques that involve the cultivation of perennial grasses and annual crops to protect the soil from erosion, restoring their fertility;
- tillage erosion techniques (contour processing, deep plowing, meleanie, katuwana) directed to arrest and accumulation of moisture in the soil;
- special techniques detention snow and snowmelt Regulation (placement machine, raking snow, lane compaction of snow);
- introduction of increased doses of organic and mineral micronutrients, liming acid soils eroded and eroded gypsum saline soils.

Agro forestry activities are characterized by erosion water-regulating and action kalimatul effect of forest litter, the effect of kecks, contributing to a more equitable distribution of winter rainfall and snowmelt, reducing the value of evaporation from the soil surface. For ameliorative action are divided into the following types [6]:

- windproof belts that are placed on the flat areas relief and gentle slopes on the borders of fields of crop rotation;
- water-regulating forest belts used on catchment slopes in the form of additional basic and auxiliary spaces, place limits on when water distribution and when network fund;
- erosion forest, bush and shrub forest strips that are placed across the slope along field boundaries crop rotation;
- pribaltov belts that serve to absorb runoff coming from the fields, improving the microclimate of the area and protecting farmland from natural grasslands;
- plantations and shrub planting on slopes and bottoms of gullies;
- hair loss severely eroded and very steep slopes, unsuitable for agricultural use;

- waterproof belts and shrub planting around ponds and along the river banks and irrigation canals and waste.

Erosion and drainage measures include the use of hydraulic structures intended to regulate runoff and securing beam systems, and production work associated with the reclamation of land damaged by erosion and development of steep slopes (backfilling of gullies and ravines, planning slopes, terracing, etc.). Depending on the purpose waterworks divided into lingering water, water guides intakes and bottom. They are created in accordance with the catchment area, the tops of the beams, ravines and along the bottom drainage.

Compared with other countries in the development of organic agriculture in Ukraine is much slower. According to the International Federation of Organic Agricultural movements and Research Institute of Organic Agriculture in Ukraine in general there are 155 organic farms.

Organic farming is based on the use of organic fertilizers, especially manure, peat, sapropel to the soil constantly growing humus - the basis of its fertility. Indeed with organic (biological) agriculture yields 10-20% lowers than in the traditional way of fertilizer, but its products on the world market is valued much more than that grown with the use of fertilizers and pesticides, sometimes 2-3 times.

Organic farming is based on the following basic principles.

- Subsurface cultivation is usually no more than a depth of 11 cm. This is mainly the cultivation of different plane plows and cultivators, disc harrows, providing sufficient loosening the top layer of fertile, weed prevention and protection from erosion.
- Elimination of fertilizers. Because proper cultivation need fertilizer significantly reduced. Use organic fertilizers should be scientifically

based standards, primarily in the form of making humus, compost, crop residues, feed liquid organic fertilizers, use of green manure (made into a separate principle).

- Denial of use of chemical plant protection products (pesticides). Ukrainian producersv "Ukrzoovetprompostach (Novograd Volynsky),"Mikoton Aglycone" (Kiev), "Center-Biotechnical" (Odessa), and others offer biological agents to combat diseases and pests of agricultural crops.
- The use of enzymes and microorganisms effective in agriculture (EM preparations). National agricultural policy in more than 50 countries based on the use of EM preparations. In Ukraine, the manufacturer is a joint Ukrainian-Japanese corporation «EMRO», which is based on Japanese material (m. Kirovograd). With the help of lactic acid bacteria, yeast, a number of other useful microorganisms enriched micro flora of the soil, which condition was considered critical, increased plant immunity and resistance to pests, extreme temperatures and adverse natural phenomena.
- The use of green manures. Green manure function as not only the replenishment of the soil organic mass, but also weed control, additions of crop rotations, increased forage and honey crop, pest, natural phyto sanitary measures.
- Scientifically grounded crop rotation. Unfortunately, adherence to "correct" rotation in our country is no longer there, so they include a separate principle of organic farming. This, according to the classical agronomy, the main measure of weed control, regulation of nutrients in the soil, is essential for maintaining its fertility and to combat pathogens.

Consequently, the disastrous state of our land requires urgent scientific and reasonable measures to improve soil fertility and ecologically clean food.

Activities aimed at soil conservation. Most soil conservation measures are proper cultural formation agricultural landscapes. In each ecosystem must be his, scientifically substantiated relationship between the field, forest, meadows, marshes and ponds. This will give the highest economic impact and preserve the environment.

No less important is the organization of business and compliance field, forage and other rotation. Save the soil and help the transition to the advanced forms of cultivation, efficient and lightweight machines and mechanisms, reducing re-cultivation, switching to subsurface cultivation.

References:

1. Primak D., et al.: *Ecological problems of agriculture.* Center of educational literature, page 456.
2. https://uk.wikipedia.org/wiki/Хмельницька_область
3. http://studenchik.ru/1-31076.html
4. Tsarik Ed. L. P.: *Foundations of environmental knowledge*. Ternopol: Ternopil, 1994, page 173.
5. Panas P. M..: *The New World - 2000*. Soil science: textbook Lviv, 2006, page 372.
6. Shvidenko A. I., Rudenko V. P., Yevdokymenko V. K.: *Ecological bases of nature management.* Kiev: SMN1999, page 200.
7. http://studentam.net.ua/content/view/5815/129/
8. http://lib.chdu.edu.ua/pdf/posibnuku/229/65.pdf

9. http://vkurse.ua/ua/business/snizheniya-plodorodiya-zemel-ukrainy.html
10. http://agrovolyn.com/struktura.php?news=495

Robert Piotr Cabaj, MSc[1)]
University of Warmia and Mazury in Olsztyn
Department of Entomology, Phytopathology and Molecular Diagnostics
ul. Michała Oczapowskiego 2, 10-719 Olsztyn
[1)]r.p.cabaj@gmail.com

Analysing the EU Biodiversity Strategy under Polish Conditions

Key words: *biodiversity, nature conservation, EU regulations*

Summary: Excessive exploitation of natural and environmental resources leads biological diversity to become ever more impoverished globally, posing a serious threat to people's health and lives world-wide. Consequently, there is a growing need for a more improved prevention of the injurious effects generated by the industry and agricultural production. Numerous action plans and strategies have been launched since the 1972 UN Conference on the Human Environment with a view to halting the degradation of ecosystems and counteracting the extinction of animal and plant species. Although these processes generate economic losses that are hard to gauge, research commissioned by the EU estimates the loss resulting from the degenerating function of ecosystems at 50 billion euro globally, with a forecast that it may account for 7% of total global consumption by 2050.[1] The policies and strategies implemented so far have done little to curb the worrying tendencies, while also failing to deliver the anticipated effect of preserving biodiversity. The aim of this paper is to analyse both the measures introduced to date and the assumptions of the new strategy under Polish conditions. The analysis is based on data provided by the State Environment Monitoring Programme.

1. Introduction

Biological diversity is a fundamental attribute of nature, one that ensures quantitative specimen balance and proportionate species distribution across ecosystems, as well as contributing to making people's lives healthier and safer. The wealth of biodiversity is a function of geographical location and structure, soil and climatic conditions, levels of social and economic development, as well as historical circumstances.

Backed by numerous environmental reports, the standpoint promoted at world conferences on nature preservation is that intensive economic development seriously disturbs species balance in the world of nature. Economic expansion, growing infrastructure and exploitation of nature's resources directly result in water, soil and air pollution, thus invariably leading to biodiversity becoming ever more impoverished globally. Therefore, it is necessary for the international community to become environmentally engaged in order to rectify this state. Numerous protocols, conventions, prohibitions and obligations have been set out since the 1972 UN Stockholm Conference and subsequently accepted by a sweeping majority of states world-wide.[2] Preservation and sustainable use of the natural heritage were the key issue debated at the United Nations Conference on Environment and Development held in 1992 in Rio de Janeiro, Brazil.[3] The conference, which is now commonly referred to as the Earth Summit, resulted in the Convention on Biological Diversity (CBD) being signed by many of the world's states, which implemented into their domestic policies a set of new standards for the protection and sustainable use of natural resources. Poland ratified the CBD in 1996, taking on all the obligations arising from its provisions.

At the European level, biological diversity preservation is one of the key elements of environmental protection and has been given the status of a priority area in the Sixth and Seventh Environmental Action Programmes (EAP).[4] In Poland, biodiversity preservation became part of the national strategy for the preservation and sustainable use of biodiversity and the Polish Action Programmes for 2003–2006 and 2007–2013. The Programmes were implemented in order to minimise the negative way in which economic activity affected biodiversity, to improve life standard in areas with substantial natural value and to prioritise these areas in access to financial support.

However, according to the Minister of the Environment, some of the programme's aims and tasks failed to be achieved. This was even despite the increased funding as compared with the first period of the Polish EU membership, which amounted to roughly 1 billion euro for the period between 2007 and 2013.[5] The money was spent on 500 projects related to natural habitats and species conservation (*in situ*, *ex situ)*, and on a range of other projects that promoted social habits supporting biodiversity preservation in Natura 2000 areas, restored ecological corridors to a passable condition and led to implementing protective measures in over 400 Natura 2000 areas. Biodiversity conservation also found its way into the Rural Development Programme, covering approximately 250,000 ha of naturally valuable agricultural land.

In spite of all these efforts, the Minister of the Environment estimated task completion rate within the National Strategy to be as low as 16%. A set of new regulations and a new action plan for preserving biodiversity in Poland were soon introduced by Resolution of the Council of Ministers No 213 adopted on 15 December 2015 approving the "Programme for the preservation and sustainable use of biological diversity along with Action Plan 2015–2020".[5] The programme was designed to elicit a greater degree of reduction in injurious behaviours and activities leading to the loss of biological diversity and to provide more effective reinforcement for the sustainable management of environmental resources while taking account of EU funding opportunities for 2014–2020.

2. Historical background

The first European document to concern biodiversity preservation was Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds (“Birds Directive”).[6] Other directives followed that concerned environmental protection and guidelines for making investment decisions impacting on the environment. Measures in this field also include the right of access to environmental information and the public’s right to participate in the environmental procedure, which is regulated by Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment.[7] It was adopted with a view to emphasising that under Article 130(2) of the Treaty on European Union, the objectives and principles of the EEC’s environment policy consist in particular of preventing, reducing and as far as possible eliminating pollution by giving priority to intervention at source.[8] Another document, Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control introduced ways to properly address environmental damage and measures designed to prevent it [9].

None of these directives made a direct reference to the conservation of endangered natural habitats and selected plant and animal species. These issues were addressed by the adoption of Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (“Habitats Directive”), which made it necessary to amend the existing directives on assessing environmental impact.[10] On 25 June 1998, the

European Community adopted the Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters. Commonly known as the Aarhus Convention, the document regulated access to information about the environment and was aimed to improve public participation and influence on making decisions that impact on the environment.

In 1993, the Council approved the 5th EAP, giving priority to integrated control of pollution and aiming to strike a balance between human activity and socio-economic development on the one hand, and natural resources and nature's regenerative capacity, on the other. The Programme set out a range of long-term environmental objectives and measures that were taken up by the 6th EAP – adopted in 2002 for the period between 2003 and 2007 – and subsequently developed in the current, 7th EAP for 2015–2020. Adopted on 20 November 2013 by Decision No 1386/2013/EU of the European Parliament and of the Council, the ongoing programme was designed to improve enforcement and facilitate active involvement of the public.[11]

3. The EU Biodiversity Strategy

Despite extensive environmental regulation, Europe is continuously losing its biological diversity as a consequence of economic development and human activity. From the legal point of view, ecosystems and animals receive adequate protection, safeguarded by the Birds Directive, the Habitats Directive, and the Water Framework Directive, the latter of which established a framework for improving water quality in the whole of the EU. Under the 7th EAP, the new strategy aims to halt the loss of biodiversity in the Union by 2020 and to restore at least 15% of degraded ecosystems in the EU.[11]

In line with the new EU strategy, improving the quality of the environment has also been made conditional on the everyday habits of the European citizens. Given this increased role of the public in protecting the natural environment, the European Commission preceded the implementation of the new programme by conducting a wide public consultation involving the participation of NGOs dealing with environment protection, public authorities and ordinary citizens of the EU. The main objective of the programme is to ensure high quality of people's lives while also protecting the planet: *Living well, within the limits of our planet*, one that is to be attained by preserving biological diversity.[11] In this respect, the environment strategy is complemented by the action plan for saving natural resources and the action plan for moving to a competitive low-carbon economy, which entails the implementation of the climate and energy package. Despite the strict regulations, air and water pollution as well as excessive noise levels continue to pose a serious threat to people's health and the quality of their lives. In this context, the programme envisages updating the regulation on air quality and noise levels, as well as changing the regulation on the quality of drinking water and the condition of seaside beaches. By the year 2018, the EU will also prepare action strategies promoting a non-toxic environment and will set out the principles for replacing hazardous and noxious substances with alternative, harmless materials.

The 7th EAP is primarily intended to attain its objectives by maximising the benefits of Union environment legislation by improving implementation, improving the knowledge and evidence base for Union environment policy, and securing investment for environment and climate policy. Although a set of very complex environmental regulations is already in place in the EU, these often fail to be rigorously observed and effectively enforced, which leads directly to further degradation of the natural environment while also rising the cost of rectifying this state.[11]

The current programme lays down a set of objectives that are to be met by 2020, mainly by reducing greenhouse gas emissions, enhancing energy efficiency, preserving biodiversity and natural resources, protecting waters and air against pollution, and improving waste management. These new objectives require new regulations to be put in place. The next step is to adopt the climate and energy package by 2030 and to achieve a reduction in greenhouse gas emissions of 80–95% by 2050. According to the EU, if enforced successfully, the Waste Regulation would enable annual savings of 72 billion euro, while implementing the clean air package could bring health benefits of up to 40 billion euro every year. It follows that successful enforcement may be considered as yet another avenue of improving the state of the natural environment. According to demographic forecasts, the year 2020 will see a majority of Europeans living in urban areas or their immediate vicinity. With this in view, the 7th EAP underlines the need for urban planning in the context of protecting the environment and preventing adverse climate change.

4. Determinants of biodiversity in Poland

Biodiversity in Poland is conditioned by the variety of its geographical regions – mountainous, lowland, coastal and maritime – as well as by its location at the frontier of the Atlantic and the continental climates. Many bird and bat migration routes cross above the Polish territory. Poland is located in the European Lowland, between the Baltic Sea and the Carpathians, and enjoys a temperate climate transitioning from maritime to continental. The country covers an area of 312,679 sq km, most of which territory (over 90%) is lowland.[12] In spite of such a decisive domination of lowlands, however, the country is strongly diversified in terms of geology, terrain relief and climate. All these factors positively contribute to the country's biological diversity and the richness of its plant and animal species. According to the present estimations, the number of species found in Poland reaches up to 60,000, including, for instance, 2,415 species of seed-bearing plants and 35,368 species of animals.[13] Biodiversity in our country is primarily determined by forests, which take up 9.1 m ha, wetlands, which cover approximately 1.8 m ha, and farmland areas, in which case only extensively cultivated areas are relevant to nature conservation. Wildlife inventory of habitats and species in state forests was conducted between 2006–2007, based on Annex II to the Habitats Directive [13].

Permanent pastures are the main site of biodiversity on farmland areas, which cover 59.9% of the country's territory. Grassland accounts for 20.7% of farmland areas and 12.4% of the country's territory.[12] This proportion is smaller than the EU average of 35.67%. Factors deemed beneficial to the preservation of biological and landscape diversity include farmland fragmentation, the rich mosaic of land parcels, as well as the maintenance of field baulks, fallows, field forestation and natural ecosystems, such as small ponds and peat bogs. The environmental status of agricultural areas is represented by the number of common birds inhabiting a given agricultural landscape, the so-called Farmland Bird Index (FBI). This is an EU index based on the number of specimens belonging to 23 bird species that typically inhabit agricultural landscape as a place of feeding or nesting. According to data of the Chief Inspectorate of Environment Protection, this index sank in Poland by 15% between 2000 and 2003, after which it slowly began to level off, finally reaching the initial state (from the year 2000) in 2005. Currently, however, the number of birds on agricultural areas is insufficient again.

Agricultural areas are home to approximately 45 Polish plant communities and approximately 700 species of vertebrates, including 395 bird species, of which 34 are strictly reliant on agricultural areas. Many bird species commonly found in Poland constitute a large proportion of their respective EU populations. These include the aquatic warbler (89.9%), white stork (38.4%), great snipe (27.7%), lark (21.2%), and corn crake (19.8%) [12].

As of today, 485 plant communities have been identified on the territory of Poland, following Braun Blanquet's phytosociological classification. The Mammalia class is represented by 105 species, while 130 fish, 18 amphibian and 8 reptile species can also be found in Poland. The country's most known protected animal species include the brown bear (164 specimens), wolf (1,122), lynx (308), the European bison (1,361), chamois (334), beaver (96,658), western capercaillie (470), and black grouse (446). The number of porpoises, which are considered to be critically endangered, is estimated at 447 specimens in the entire Baltic Sea area.

Before Poland's accession to the EU, the principles governing environment protection and nature conservation were regulated by two main acts: the Act of 16 April 2004 on nature conservation (Journal of Laws of 2004 No 92, item 880, as amended) and the Act of 28 April 2001 –

Environment Protection Law (Journal of Laws of 2001 No 62, item 627, as amended). After Poland's becoming an EU member state, these acts were amended in compliance with the Union's environmental Directives. The types of legally protected natural habitats are currently specified by the Regulation of the Minister of the Environment dated 6 November 2013 (Journal of Laws of 2013, item 1302) on the subject of natural habitats and species of interest to the Community and the criteria of qualifying areas for recognition or designation as Natura 2000 areas.

During the first period of Poland's membership of the EU, the principles and priorities of biodiversity preservation were determined by the National strategy for the preservation and sustainable use of biodiversity along with Action Programme 2007–2013. The primary objective of the National strategy was to preserve the richness of biodiversity on the local, national and global scale, and to secure the durability and developmental potential at each of its organizational levels (intra-species, inter-species and supra-species), while taking into account the requirements of Poland's socio-economic development and the need to secure proper living and developmental conditions for its society.

In 2008, the first government report on environment protection was drafted. It gave little attention to the problem of biodiversity and species and area protection. The report was adopted by the Council of Ministers on 8 July 2010, that is, two years after it has been drawn up.[13] By that time, new amendments of EU regulations and regulations of the Minster of the Environment had entered into force, including Regulation of the Minster of the Environment of 10 May 2010 (Journal of Laws of 2010 No 77, item 510) on the subject of natural habitats and Natura 2000 areas.

The European Natura 2000 network covers areas of greatest natural value located within the boundaries of national parks and reserves. After the additions of January 28, 2014 were approved by the Council of Ministers, the Polish Natura 2000 areas include 849 areas and 144 habitats of special bird protection. In total, these areas take up approximately 20% of the country's territory.[14] The Natura 2000 areas are catalogued and protected by the General Directorate for Environmental Protection. Each nature complex requires an individualised programme of protective measures. The compilation of the wildlife inventory and the drafting of protective plans for the areas of natural value in Poland began in 2007 and, as of today, the inventory includes almost all protected areas.

5. Effects of biodiversity preservation measures

Since Poland's accession to the EU, knowledge about the distribution and conservation status of species and natural habitats in the country's territory have improved significantly. The inclusion of Poland into EU structures has had a two-way impact on the state of the natural environment and biodiversity preservation. On the one hand, new possibilities for economic development and funding of pro-ecological projects were created; on the other, the funding of economic development has put increased pressure on the environment. In 2006, two programmes of environmental monitoring were launched in Poland: birds natural habitats monitoring, including monitoring birds on the Natura 2000 areas and within the special habitat protection Natura 2000 areas that comply with the Habitats and Birds Directives. According to data provided by the State Environment Monitoring Programme for 2007–2012, most of the natural habitats and many bird species within the Natura 2000 areas and in state forests in our country enjoy a good preservation status, which is still improving. By comparison, the state of environmental protection in agricultural areas, including the state of monitored meadow, grassland and peat bog habitats, is unsatisfactory or bad.[15] The FBI in the years 2012 and 2013 was 16–18% lower than in 2000, and in 2013 – as much as 41% lower compared with 1993.

In a report on the state of the environment published in 2015, the EU assessed the state of protection of approximately 2,000 species and habitats covered by the provisions of the Birds Directive. Not all the assumed objectives and tasks had been met. Endangered habitats and species included 81 types of natural habitats, 40 plant species, 80 animal species and 74 bird species specified in Annex I to the Birds Directive, as well as 83 additional migrating bird species. The distribution of many species in Poland is still pending identification and yet many valuable bird and plant species, such open pasque flower and mountain arnica, are clearly disappearing from the Polish landscape.

The list of endangered plant species in Poland is quite extensive and still getting longer. The *Red List of Plants and Fungi in Poland* (2006) holds 506 vascular plant species that are endangered, extinct or lost, which account for 21% of the country's flora in this group, with 144 species being critically endangered at the moment. *Polish Red Data Book of Animals – Vertebrates* (2001) enlists 130 species endangered with extinction, 76 of which are critically endangered. The highest threat of extinction among birds applies to 7 galliform species, 5 of which have already been recognised as endangered.[13,15] The preservation of nature's resources also extends to cover the Baltic Sea and the 2,005 sq km of its internal sea waters, 8,682 sq km of territorial waters and 22,634 sq km of the exclusive economic zone. Sea mammals inhabiting the Polish waters include 4 species: the great seal, harbour seal, ringed seal and the only Baltic whale – the harbour porpoise, a species that is still to enjoy adequate protection. The Baltic Sea region is home to 340 bird species, most of which migrate between wintering sites and the areas of their spring and summer breeding. A total of 4.41 m waterbirds is estimated to have spent winters in the Baltic coastal region between 2007 and 2009, which is a substantial drop compared with 1993. The sharp decrease in birds inhabiting the coastal regions is attributed to habitat loss resulting from sea management, coastal fishing and aggressive tourism. Lampreys are among the fresh-water animals threatened with extinction in Poland, and among bi-environmental species – the Atlantic sturgeon, salmon, sea lamprey, allis shad, vimba, and huchen.

Species conservation of breeding animals and plants is also carried out at the level of the national agricultural and environment policy. Poland is home to 90 breeds, varieties and strains of the livestock covered by genetic resources conservation schemes as well as an aid scheme launched in order to ensure natural breeding conditions, free-range farming, organic feed, and access to highly-diversified pastures.[17]

5. Conclusions

In line with the EU perspective, the year 2020 has been set as the deadline for boosting the number of assessments of the habitats and species specified in the Habitats Directive (by 100% and 50%, respectively), and for increasing the number of assessments of the species specified in the Birds Directive (by 50%), and therefore for improving their protection.[11] Taking account of the Polish conditions, the less-than-4-years of time available and the existing knowledge on the EU Biodiversity Strategy implementation, the indicators quoted above simply seem beyond reasonable reach. The Polish Natura 2000 network receives no scientific support that would be equivalent to the aid provided by the European Environment Agency's European Topic Centre. Moreover, it was only at the close of the last year that the Polish Council of Ministers adopted three relevant science and research programmes and provided the financial resources for their implementation. However, even though the programmes are set out to facilitate sustainable agriculture and biodiversity preservation, it will take time to have them prepared in detail and implemented to the end of ensuring genetic conservation of plants and animals.

An amendment of the Polish Nature Conservation Act is projected for as late as after 2017, while an audit by the Minister of the Environment has shown gross inconsistencies and delay in the implementation of the EU environment regulations and consistent failure to use EU funds. What is more, studies and reports prepared at the national and regional levels demonstrate the public to have inadequate knowledge of and be less than ideally involved in tackling the challenges of environment and biodiversity preservation. The EU strategy assumes the level of degraded ecosystems restoration to reach 15% by 2020, yet the degraded environment and historical neglect is subject to virtually no monitoring, which is especially true for agricultural areas. In sum, even though the Action Programme for 2015–2020 establishes particularly ambitious and specific objectives that are in line with EU directives, its timely implementation appears to be severely jeopardised by past delay coupled with a lack of scientific support.

References:

1. European Food Safety Authority: Report 1/2013.
2. Radziejowski J.: *Obszary chronione jako forma zarządzania różnorodnością biologiczną* [Protected areas as a form of managing biological diversity]. Wszechnica Polska Szkoła Wyższa TWP, Warszawa 2010.
3. Raman S.: *Agricultural Sustainability: Principles, Processes, And Prospects*. Food Products Press, An Imprint of The Haworth Press, New York – London – Oxford 2006. ISBN-10: 1-56022-311-1.
4. Sixth EU Environment Action Programme 2007–2013.
5. Council of Ministers of the Republic of Poland: Programme for the preservation and sustainable use of biological diversity along with Action Plan 2015–2020.
6. Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds.
7. Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment.
8. Treaty on European Union.
9. Council Directive No 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control.
10. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.
11. Seventh EU Environment Action Programme 2015–2020.
12. Central Statistical Office: Statistical Yearbook of the Republic of Poland 2014.
13. Chief Inspectorate for Environmental Protection: Monitoring species and natural habitats.

14. General Directorate for Environmental Protection: Monitoring Natura 2000 areas.
15. Chief Inspectorate for Environmental Protection: Report on monitoring status in Poland in 2008.
16. Committee on the Environment, Public Health and Food Safety: Draft report on the mid-term review of the EU's biodiversity strategy (2015/2137(INI)).
17. Ministry of Agriculture and Rural Development: Rural Development Programme 2014–2020.

Yaroslava B. Mosiichuk, Tetiana P. Khomutetska
Kyiv National University of Construction and Architecture
Ukraine

Structures with adjustable and unregulated pumps in the water supply without tower

Key words: *unregulated pumps, pipeline system*

Summary: The article examines various cases of reckless operation of tap systems with regulated and unregulated pumps, it was analyzed the peculiarities of parallel operation of different types of pumps. Research has shown dependences to determine the performance of pumping units. The efficiency of frequency converters in the water supply was considered.

1. Formulation of the problem

The study of existing water supply systems show that towns eventually change the rules and modes of consumption, and characteristics of water supply facilities, leading to the creation of excess pressure in the network and increase its accident rate, of a conflict between design and actual operating data of the water system, lack of consumer spending and required water pressure. In many cases, the pump is outside of the recommended use, i.e. with low efficiency and high energy consumption, and therefore much of the current pumping equipment in Ukraine requires replacement or reconstruction.

2. Analysis of recent research and publications

Among the components that form the cost of water for municipal enterprises, usually the largest share of the costs for the consumption of electricity. Thus, an important task at present is to ensure the effective operation of pumping stations that would meet the estimated demand for water consumers with minimal power consumption. This can be achieved by studying and calculating different options of regulated and unregulated pumps and determine appropriate parameters and modes of operation when you change the water.

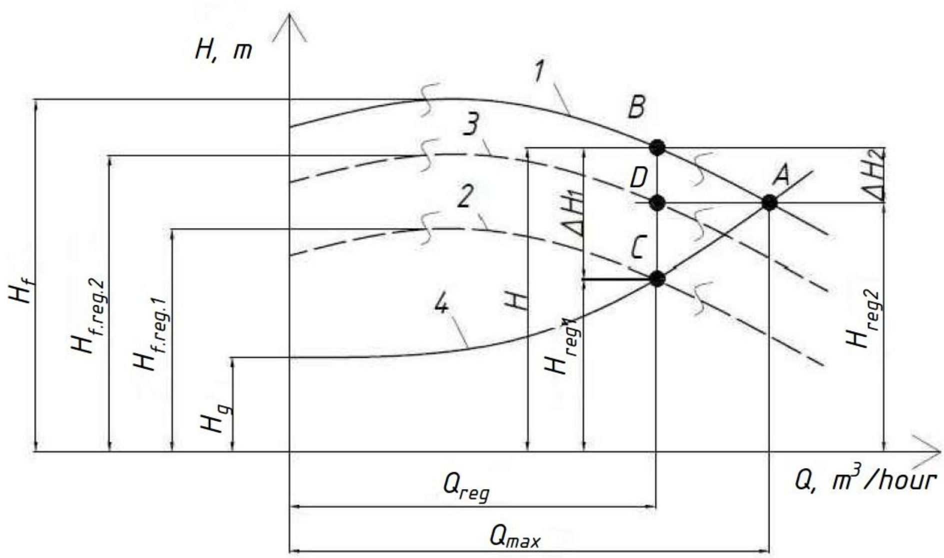
The most complex situations arise when the joint operation of tap systems of reduction in water intake. As a result of obsolete equipment and inefficient use of pump units there is overpressure in the pipe lines, and a large depreciation of utilities recorded a significant number of accidents. This made a significant overruns of electricity that under the relentless growth of its value leads to a significant increase in operating costs of utility companies. This fact causes the rising water cost and the increase in tariffs for consumers.

3. Formation aims and objectives of the article

To solve these problems need to ensure energy-efficient joint operation of facilities in water supply system. This can be achieved by reconstruction of pumping stations, setting them modern pumps with frequency converters and determining the optimum operating parameters of pump units, when the calculated value of feed and provide water pressure minimum energy performance.

Main part: For example, consider the different cases of operation of regulated and unregulated pumps and pipeline systems in without tower water network (Fig. 1).

Figure 1. Charts collaboration hydraulically interacting structures



1 - characteristic of Q-H unregulated pump; 2 - the same as the regulated pump;

3 - the same as the regulated pump when Hr = const; 4 - Pipeline System

Source: Own elaborated

Working point of operation of water works system will be point A, formed at the intersection of lines 1 and 4 of the characteristics of the pump and piping.

Using the value of neutrophils and analytical characteristics H_f and S_f of schedule 1, the pump head H, m, changing consumption Q can be determined from the equation [2]:

$$\boldsymbol{H = H_f - S_f\, Q^2} \qquad (1)$$

Figure 4 build, knowing the generalized system of hydraulic resistance of water Su (communications pumping stations, water pipes and networks) and the geometric height of water lifting Ng. The required pump head, m, for a speaking point network design pressure by changing the water Q is determined by the formula:

$$\boldsymbol{H = H_g + S_h\, Q^2} \tag{2}$$

Maximum supply pressure pump counting Hr necessary to maintain the desired pressure in dictating free point in the hours of highest water consumption from the net amount Q_{max} (Fig. 1). As the water pumping to the value Q_{reh} unregulated pump creates excess pressure in the system ΔN1 size and operating point shift in position B. In this case, in addition to increasing the origins and growing threat to the establishment of emergency networks and conduits, the pumping station there are significant cost overruns electricity.

As you know, the power consumed by unregulated pump shaft, kW, can be defined as follows:

$$N = \frac{QH}{102\eta} \tag{3}$$

Where:

Q; H and η - under supply, l/s, pressure, m, and efficiency in the fate of the unit of the pump.

To eliminate excessive pressure while reducing water consumption from the grid in the water supply increasingly began to use frequency regulation pumps by changing the rotation frequency of impeller, which

is carried out by pumping stations installed on the current frequency converters.

In the case study regulation pump (Fig. 1) in the water supply Q_{reh} would create pressure in the system $N_{reh.1}$ hydraulic characteristics of the pump Q-H would take the position 2 of a working point C. At this point in speaking network would be provided free desired pressure at significantly lower power consumption.

In this case, the rotational speed of the impeller pump is controlled, min^{-1}, can be defined as follows:

$$n_{reg} = n\sqrt{\frac{H_{f.reg}}{H_f}} = n\sqrt{\frac{H_f - \Delta H}{H_f}} \quad (4)$$

where:

n - speed impeller pump catalog (unregulated), min^{-1};

N_f and $N_{f.reh}$ - analytical characterization lifting pump at zero supply, m;

ΔN - excess pressure pump meters.

Supply and pressure controlled pump is determined using the relationship:

$$Q_{reg} = Q\left(\frac{n_{reg}}{n}\right) \quad (5)$$

$$H_{reg} = H\left(\frac{n_{reg}}{n}\right)^2 \quad (6)$$

When submitting largest known values Q_{reg} to the consumption of network consumption on the regulated pump shaft, kW, are given by:

$$N_{reg} = N\left(\frac{n_{reg}}{n}\right)^2 = N\left(\frac{H_f - \Delta H}{H_f}\right) \quad (7)$$

Given that water throughout the day all the time, it would change the required parameters as costs and pressure pump. Adjust pumps for these two indicators are very difficult, so the pumping stations typically perform pump regulation, taking constant pressure estimated value (H_r=const), defined for Q_{max}.

In this case, the supply pressure Q_{reg} and $H_r = H_{reg.2}$ characteristics of the pump (Fig. 1) takes a position 3, work will point D, excessive pressure drop in the value ΔN2 and consumed on the pump shaft power is determined by the formula:

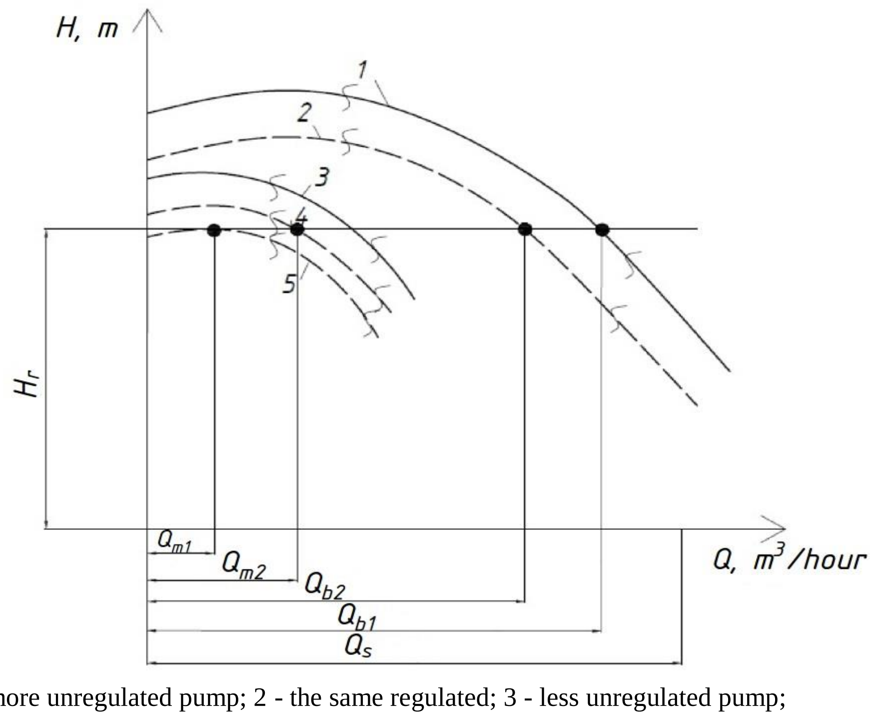
$$N_{reg} = N\left(\frac{n_{reg}}{n}\right) = N\sqrt{\frac{H_f - \Delta H}{H_f}} \tag{8}$$

Using the abovementioned dependencies, you can determine the necessary operating parameters of pumps for reducing water consumption and analyze the results of calculations of energy consumption when operating the regulated and unregulated pumps.

As without tower water systems to ensure the effective operation of pumping stations at different modes of consumption often use different types of pumps. However, given that the installation of frequency drives are quite costly, to save money in case of reconstruction of the pumping station sometimes one electric set for a group of 2-3 pumps [5]. However the practical operation shows that in this case there may cavitation, increased dynamic loads on the bearings and shafts of pumps, reduced efficiency and ultimately reduced efficiency of the system as a whole. Studies have shown [1, 3, 4, 5, 6], that under this scheme often pump frequency regulation is in invalid workspace, resulting in uneven recorded additional noise and vibration, which causes premature wear of the pump and its yield down. Such processes are particularly common in the low-performance pump when lifting characteristic has a negative slope.

Consider the parallel operation of different types of pumps in this sample (Fig. 2). Where the water pumping system Qs slightly exceeds the maximum flow of unregulated pump Qb.1, filing another regulated pump can Qm.1 a given predetermined pressure H_r be outside the recommended application, and if the operating point stays on downward curve period 5 will be observed unstable pump that accelerates its wear parts. Therefore, the reconstruction of pump stations is desirable to provide frequency regulation for the whole group set during installation of pumps and modes of supply to ensure each pump (Fig. 2) in its operating range (Qb.2 and Qm.2), which helps smooth functioning units with high efficiency.

Figure 2. Image Q-H characteristics of two different types of centrifugal pumps:



1 - more unregulated pump; 2 - the same regulated; 3 - less unregulated pump;

4, 5 - the same regulated

Source: Own elaborated

As shown by studies conducted on the existing water supply systems [1,5], regulating pumps can reduce electricity consumption by an average of 25-30%, which significantly reduces the operating costs of utilities.

It should be remembered that the research collaboration pumps should always check whether the feed pump each running in the area of its recommended use. Exploring various options of each pump station design value of water, you can set the optimum mode and operating performance of pumps, which provide the lowest power consumption.

Therefore, optimizing the work of pumping station in without tower water supply system and automating management processes based on changes in water consumption during the day, can provide the estimated pressure in dictating points in the network and water consumption for the needs of the locality with minimal power consumption.

4. Conclusions and recommendations for further research

Changing the rules and modes of consumption in settlements and characteristics of water supply facilities hydraulic interaction during prolonged use leads to a situation where part of consumers not provided the necessary costs and water pressure, and the work of existing pumping equipment is outside the recommended application, i.e. low efficiency and high power. One solution to this problem is the reconstruction of pumping stations, installation of pumps with frequency control and automation of management processes tap system.

Presented dependence can determine the parameters of regulated and unregulated pumps, analyze calculation results system with different possible versions of the works and to determine the best modes of different types of pumping units with the lowest power consumption. Application of frequency control and selection of pumps economically viable modes of operation make it possible to reduce power consumption for water pumping stations by an average of 25-30%.

Literature:

1. *Хомутецька Т.П.* Способи енергозбереження у водопостачанні Проблеми водопостачання, водовідведення та гідравліки: наук-техн. зб. Вип.24. – К.: КНУБА, 2014.– С.257-264.
2. *Хоружий П.Д.* Расчет гидравлического взаимодействия водопроводных сооружений. – Львов: Вища школа, изд-во при Львов. ун-те, 1983. – 152с.
3. *Лезнов Б.С., Воробьев С.В.* Работа центробежных насосов с переменной частотой вращения // Водоснабжение и санитарная техника, 2012, №9. С.48–56, №11. – С.44-49.
4. *Багаев Ю.Г., Карпов Н.В., Усачев А.П.* Параллельная работа насоса с частотно-регулируемым электроприводом Водоснабжение и санитарная техника, 2014, №4. – С.38–41.
5. *Шкінь О.М., Хомутецька Т.П., Хоружий П.Д.* Шляхи енергозбереження в системах господарсько-питного водопостачання на прикладі Чернігівського водопроводу Водне господарство України, № 2 (104), 2013. – С. 18-22.
6. *Никитин А.М., Балыгин А.В., Шустова Г.И., Яковлев И.М.* Особенности частотного регулирования параллельно работающих насосов, Водоснабжение и санитарная техника, 2014, №4. – С.42–44.