FACULTY OF CIVIL AND
ENVIRONMENTAL ENGINEERING
BIAŁYSTOK UNIVERSITY
OF TECHNOLOGY

POLISH ASSOCIATION
OF SANITARY ENGINEERS
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SERIES OF MONOGRAPHS

„ENVIRONMENTAL ENGINEERING – THROUGH A YOUNG EYE"

VOLUME 28

WATER MANAGEMENT AND PROTECTION

Edited by
Iwona Skoczko
Janina Piekutin
Łukasz Malinowski
Magdalena Horysz

Białystok 2016

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i Gospodarki Wodnej w Białymstoku

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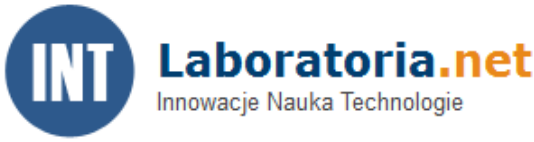

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ISBN 978-83-62582-95-2

Oficyna Wydawnicza Politechniki Białostockiej

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Environmental and economic importance of tourism for the development of the region on the example of the Warmia-Mazury

Keywords*: environment, economy, tourism*

Summary: Warmia and Mazury voivodeship is, in the opinion of Poles, one of the most attractive and is occupying in this category the 3rd place in the country after the coastal areas and mountains. But still in terms of tourist arrivals this area is one of the least eligible regions of Poland. The biggest educational center of science and opinion is the University of Warmia and Mazury, where nearly 40 thousand people are studying in different forms of education. For many years, the main field of the economy, is agriculture and small shipbuilding industry, furniture and agri-food processing. Despite the high development potential, the region remains one of the poorest regions in the country, with constantly high unemployment rate. The unique qualities of nature and landscape are not sufficiently used for the development of tourism, which could be an engine for economic development in poor villages. The subject of the study is to analyze the causes of the condition and possible changes on the basis of statistical data and own research.

1. Introduction

Tourism as a branch of the economy which occupies a significant place in the number of income. In 2014, the share of this sector in world GDP was 9.8% and the value of wages amounted to US $ 2.4 trillion. The development of this sector in 2014 has brought the world's 2.1 million new jobs and 6.1 million in areas related to tourism. It is estimated that tourism provides 277 million jobs and this industry will continue to grow rapidly.

Multidirectional development of tourism and its socio-economic importance had a big impact on the development of every individual country and region, which also reflected to our country and the region of Warmia and Mazury. Tourism not only provides jobs for millions of people and contributes to the improvement of their living conditions, but also leads to a wide cultural exchange, broadened experience and integration of societies. Tourism also promotes joint actions for development and peace and security in the world.

According to GUS data, the share of tourism in the national GDP in 2013 was 6.4%. Comparing to data from 10 years ago, today the value increased by 2.5%, but still the number remains lower than the average number in the world. The reason is the weather. The climate just offers a relatively short period for year-round recreation with a limited ability to offer good conditions.

Tourism is set to profit from the exploitation of existing social sciences resources. Assuagement the needs of tourists, however, collides often with the rigors of the environment and the requirements of the protection of nature and culture, elements of which are legally protected under national and international laws, conventions and directives. Taking investment actions in the area of tourism and analysing their implications should be noted. That almost always interferences in a defined space and socio-cultural order, which can cause irreversible changes in the environment. The chance is the realization of principles of sustainable development of infrastructure and tourist facilities. In localities with high natural values, high unemployment and lack of industry, these principles and the possibility to use them should organize and promote specialized tourism and create brand local product. Creating conditions for the

development of local tourism will have a direct impact on the economic development of the site and the region.

1.1. The history of the development of tourism

The movement of people is an inseparable part of human development. The first migrations resulted only from the need to search for and acquire new places to settle, more friendly in terms of climate and economy. With the development of civilization evolved motivations wanderers. To new, unknown places traders, explorers, treasure hunters and the seekers of natural and cultural attractions have travelled. Travel also has a religious character. Tourist routes to places of worship, marked in front of hundreds of years, remain unchanged until this day. In ancient times, travel was undertaking as a very risky and costly exercise. It also required an extraordinary resistance to the hardships, discomforts and risks during long travels, but at the same time the science and knowledge about the whole world had been developing. Travels overseas and explorations of the new lands were financed by kings and wealthy merchants, counting on profits from trading overseas goods. Along with the technology development, the way of traveling had changed and the travel time had shortened. Stagecoaches were ousted by the railway, steam ships and cars and airplanes.

With the progress of civilization and socio-economic changes, travels became available to the wide public, and tourism has gained international significance [1]. The first trails and tourist guides were created.

Advantages and benefits of relaxation at spas, Poles have discovered very early [2], but flourishing of the tourism took place only in

the second half of the nineteenth century. At that time, the first spas in Krynica, Sopot and Swinoujscie were created, and the hill walking were developing. At the turn of the century a rapid development of health tourism and recreation took place throughout Europe. Along the shores of the Mediterranean and the mountains fashionable spas and hotels were created. The number of people who had been traveling during this period increased twice [1]. The first companies and tourist organizations were created. This condition was interrupted by World War II.

The reconstruction of war damage quickly influenced the tourist industry. The national tourism developed and popularized an active way of spending free time in the outdoors and the development of various forms of hiking, canoeing and skiing [3]. In the Tatra Mountains began to work skiing in masse. Zakopane has been developed. New rails and roads, hostels, hotels and new resorts were formed in the Sudetes Mountains, in Krakow, Mazury Lake District and the Baltic Sea. The sea and the mountains became a common destination of the internal travels and holidays. The two largest tourism organizations were connected: Polish Tatra Society and the Polish Tourist Association. It was established as Polish Tourist and Sightseeing Society. The activities which are most popular in Poland today are delineating footpaths, hiking, riding, cycling and water trails, promotion of qualified tourism and the publication of maps and tourist guides. Weekend trips for recreational purposes became popular as well.

Tourism began to become increasingly important, especially among the urban populations. Poland remains out of reach and free access to foreign resorts. Meanwhile, in the world, in the years 1950 to 1996 the number of foreign tourists increased more than 23-fold. In contrast,

in Poland in the 80s there was another collapse in tourism due to the political situation in the country, strikes, martial law, unemployment, bankruptcy of many companies, including resorts, low quality of services, lack of communication and unpolluted lidos. But the political changes in 1989, such as open borders, new customs regulations, currency and passport, permitted on the reconstruction and development of the tourism. New hotels and guesthouses were build which offered services based on the higher European standards. The number of travel agencies, hotels and boarding houses in the 90's in Poland increased by a few thousands. International bus transport, rail network and air transport have been developing. The new gastronomic locals were formed that have been offering high quality and variety of food. The number of travellers going abroad has increased, as well as the number of travellers coming to Poland from different parts of the world [3]. Tourism had become an important factor in the economic development of regions.

1.2. Definition of tourism and its forms

Tourism, comes from the word ‘‘tour’’ found in the same wording and spelling in French and English. Translated, the word “tour” is a journey from the place of residence ending back to the place of departure. The concept of tourism has many definitions. This is due to a number of phenomena associated with the travel and stay of people in a new place. According to Plocka, tourism means moving to another location without the exercise of the gainful employment or change of residence [2]. The concept of tourism is similarly interpreted by the French economist W. Hunziker, who is describing it as trips for purposes unrelated to employment. According to Mazurski (2006), tourism is travelling

for recreational purposes. This strong ties highlighting the lack of work and travel, and emphasis on the state of the pleasure of traveling and recreation elsewhere appears in the most scientific analysis and interpretation. Przeclawski (1973) has defined tourism as a whole ‘‘phenomena spatial mobility, related to the voluntary, temporary change of residence, the rhythm of life and the environment, and the entry into personal contact with the environment visited (natural, cultural or social)’’. Tourism is the subject of research of many scientific disciplines including economics, sociology, law, biology, geography, wildlife and cultural heritage. The focus of economic sciences are issues related to the economy of tourism, economics of tourism market of tourist services and tourism destination in the national economy and local development [4]. The analysis and research are environmental monitoring the impact of tourism on the changes in the environment and protected areas.

There are a number of broader concepts and terms related to tourism and the tourist industry. To standardize concepts in this area, and for statistical purposes, the tourism definition of the United Nations World Tourism Organization (UNWTO) in 1993 was accepted by the United Nations: ‘‘Tourism is a totality of activities of persons travelling and staying in places outside their usual environment for a period not exceeding 12 months, in leisure, occupational or other’’ [1].

With the definition of tourism is closely linked a definition of tourist, traveler or tourist traffic participant also called visitors. The most general term in common, is a tourist or a traveler. This term describes a person moving for tourism inside the country or abroad [5]. In our country, the definition of a tourist is defined in the act of tourist services, according to which, the tourist is ‘‘a person who travels to another place

outside his permanent place of residence for a period not exceeding 12 months, for which the destination is not taking a permanent job in the visited locality and who use the accommodation for at least one night''[6].

Today there are many forms of tourism. Classification of forms depends on the location and scope of government, the motives of traveling as well as how to implement the theme of travel, curiosity of places, specifics interests and expectations of buyers the travel services. According to Plocka (2009), basic tourism division comes from its territorial and national scope. In this way she mentions the national outbound tourism, inbound tourism and international tourism. A much wider division of tourism into categories, is identified by Balinska (2013). These categories are listed in the following order: health tourism, sanatorium and health resort, regenerative-aesthetic, medical, sightseeing, religious, active (qualified), sports, ethnic, business, motivational, corporate, marine, alternative, natural, hunting, fishing, eco-tourism, cultural tourism, literary, folk, military, culinary, rural, post-industrial, social, hobbyist and weekend. So the widely specialized division refers both to the domestic and the foreign offers. In the country, most often we deal with the so-called mass tourism which is based on linking tourism sightseeing with recreation and leisure time. From the point of view of the economic and environmental conditions of the region, an important place occupies such forms of tourism, which take into account natural and cultural values of the region and highlight the historical values, traditions, legends and specific regional and local. They include sustainable tourism, ecotourism, cultural tourism and heritage tourism.

Sustainable tourism is based on sustainable use of resources, tangible and intangible environment, to maintain a balance in the economic, social, environmental and spatial. The result of the development of these forms of tourism should be a real increase in the level and quality of life of people. Both for the inhabitants of the regions as well as for the tourists. This form of tourism refers to the organization and sharing of space tourists and the method of management of tourism. It depends on the decision of local governments, tour operators and organizations that promote alternative tourism.

The second type of tourism called eco-tourism and cultural tourism, refers to the activities and interests of travellers themselves, their way of movement in the protected natural and historic areas.

Ecotourism is offering touring which is responsible ecologically, respecting the environment and cultural heritage. Eco-tourists are mostly interested in exploring natural areas, unchanged by civilization and the enjoyment of watching the riches of nature, nature shaped by nature or human beings. This form of travel promotes the protection of nature and has only a slight impact on the environment. By this treatment the local wealth of nature, the opportunity is given to socio-economic involvement of local communities in preparing and promoting a tourism product. This form does not require a large investment, and contributes to the protection of natural and cultural heritage, and the community should benefit from this type of financial solutions.

To the forms of tourism that are involving tourists themselves, belong also cultural tourism. This phrase is used to describe the traveling in order to get to know places and objects of material culture and spiritual. This form of tourism includes visiting historical and archaeological sites,

visiting industrial heritage, old factories, canals, bridges, railway lines and also getting to know local traditions and customs, participation in folk ceremonies and cultural events. Person choosing this type of tourism are driven by other motives than ordinary travellers. They want to experience closer contact with the public, to know and understand better the history and the local customs. Usually, this involves the need to return to the sources of knowledge about their own lost past or places of origin of lost loved ones. A special type of tourism is tanatotourism, associated with the search for old cemeteries and burial sites, mostly from the period World War I and II. By experiencing neighborhood and local culture, this explores the unknown fate of the people, the common conversation and participation in local rituals and customs. Furthermore, close relationships can be established and the journey is organized on a more human and personal level. Cultural tourism leaves a lasting impression on the memory, makes travel more social with human connotations, sensualizes on the mutual relations of people and the environment, and let understand deeply the age-old ties with the natural and cultural heritage. Cultural tourism of the older generation, mainly popular in the former territory of East Prussia, is often connected with the need to find specific historical sites or the return to forgotten places of childhood.

1.3. The importance of tourism in socio-economic term

Tourism has many functions of social importance, such as leisure, educational, health and cognitive, and from an economic point of view, the most important is an economic function, shaping the tourist market. These functions affect the isolation of the various forms of tourism that are formed depending on the themes of travel, age rating and the time and place

of residence. Today, tourism is becoming more and more variety and specialized, addressed to a specific recipient. The progress of civilization, the increase in wealth of society, changes in time and work, mobility and fashion activities stimulate the development of specialized tourism, which results in ever-increasing demands and expectations of the organizers of tourism, in terms of attractiveness of services. The development of tourism is also affected by political and social factors, such as the free movement of persons, goods and services within the common market and the abolition of borders in the European Union. With these changes, tourism is easier to implement and is not only an important element of economic development of the country, but also a simple way to direct communication and international integration.

The main significance of tourism for economic development is their economic function. To this function as a whole influence historical conditions, environmental, economic and social. Economic conditions of tourism are the relationships between tourism, economy and society. They are creative features that contribute to the formation of the Gross Domestic Product. At the stage of the provision of services by companies, institutions and tourist organizations, [7] we deal with auxiliary, complementary functions.

Economic functions are the result of the impact of tourism on economic growth, income redistribution and influencing the balance of payments of the state [5]. These features contribute to the creation of new sources of income and increase revenues to the local and central budgets. Economic functions of tourism take place in the national and foreign scale. Foreign exchange flows are parts of foreign trade. Foreign travellers and arrivals are usually richer than the local population, also

indirectly affect the improvement of living conditions and contribute to closing the gap in living standards of societies [8].

According to Konieczna-Domanska (2012), the basis of the economic importance of tourism is the creation of additional economic activity and create new jobs. The increase of employment leads to the increase of incomes and improve the quality of life of residents. They generate income from tourism taxes and increase revenues to local budgets and the Treasury. Tourism promotes activation of economically underdeveloped areas and solves unemployment problems. The resulting earnings increase the demand on consumer goods which, in turn, improve the quality and standard of living of the population. Proceeds to the budget allow for the development of road infrastructure and recreation, construction of new public facilities, sewage treatment plants and tourist attractions.

1.4. Environmental conditions of the development of tourism in the studied region

It is assumed that the most important factor in stimulating the development of tourism, are the needs of human and his motivations, but the development of tourism determines the primarily state economic policy and the environment, to whom we owe the creation of protected natural areas, the financial system and for tourism development. The development of tourism is heavily dependent on the environment, its diversity and possibilities of use for tourism. Environment, the historical, cultural and natural heritage of the region are crucial for the attractiveness of the tourist offer. Warmia and Mazury has a rich history and unique in the country's

natural and cultural values. It offers its visitors a number of high-class historical monuments, clean environment, rich natural and cultural events.

Warmia and Mazury is famous for its exceptional natural assets, the wealth of lakes and forests, clean air, beautiful landscapes. Compared to other regions, this region is a leader in environmental cleanliness. It is characterized by higher than average in the country the percentage of treated sewage (in the region of 95.3%, the national average: 90.3%) and higher than the national average percentage of the population using waste water treatment plants (in the country is 58.2%, regional 67.5%). All cities province discharge into wastewater. Warmia and Mazury is called the land of a thousand lakes although in fact there are more than 3,000 lakes. The region is characterized by an abundance of greenery, vast areas of tourism and diversity of flora and fauna [9].

The province is a part of the so-called Polish Green Lungs. On the one inhabitant of the region accounts for 7.8 thousand m^2 of natural areas protected by law, which exceed the national average almost three times. In the area of the region there are four national parks (Bialowieza, Wigry, Biebrza and Narew), one hundred and four nature reserves, eight natural parks and more than two thousand natural monuments. Protected areas occupy almost half (46.1%) of the surface region. The most popular and the largest holiday resorts and water tourism facilities are located in Gizycko, Ostroda and in Mikolajki. The province has favorable conditions for the development of various forms of tourism, including agri-tourism. The population of the region from ancient times have lived from agriculture, and today has to offer historic landscape as a unique product of rural tourism, monuments, traditional products and cultural heritage of the region.

The history of Warmia and Mazury is of great importance and influence on the development of new forms of tourism, especially foreign visitors and motives. The largest group of foreign tourists are Germans, and this group has particular tastes and interests, related to the history. The region is located in the area of the ancient lands of East Prussia, which were created in 1772. The history of the Warmia and Mazury consists the history of Poland, Russia, Germany, Lithuania and Scandinavia. Name ‘‘Warmia’’ is used from 1250 until the present time. It comes from an old Prussian expression ‘‘Wormyan’’ or ‘‘Wurmen’’. This area was inhabited from the beginning by Catholics and managed by Catholic bishops. The symbols of the religiousness are roadside crosses, chapels and churches. The name ‘‘Mazury’’ was introduced by the Prussian authorities. In times of peace, the population has lived in correct, cultivating their own culture, customs and religious diversity: Catholic, Protestant and Orthodox. Over the history of the area has become a hotbed of Prussia and the site of many conflicts and wars. To this day can be found in the forests many necropolis from the period World War I and II. After World War II, East Prussia was divided. Part of Warmia and Mazury included to Poland and the area of Kaliningrad Oblast, to the USSR. Post-war period did not bring significant economic changes. Warmia and Mazury remained the region with the low standard of living. Political changes after 1989 contributed to the increase in unemployment, bankrupt companies and increasing poverty. The situation improved only after the entry into the European Union. Today, the region is building a development strategy based on stimulating economic activity, modern technologies, mobilization of society and the use of natural resources.

2. The study area

2.1. Characteristics of the study area

Warmia and Mazury in its current form was created in January 1999. And it is close to your area in 70s, when there were 17 provinces. The country has undergone two major administrative reforms. After 1 June 1975, in a place of the 17 provinces, was founded 49. It was the political and economic intention. It was aimed at the construction of new centers of local power, two-stage (province, districts), and stronger economic development of the poor villages. Small provinces, often do not have even a million inhabitants were created. After the transition period the concept of strong provinces and three-division of power in the region counties and municipalities were restored.

16 provinces with greater economic potential were created, and the division remains to this day, although it was not always justified economically or environmentally. Olsztyn voivodship was created from the former Olsztyn and Elblag and part of the provinces of Torun, Suwalki and Ciechanowskie. To the Olsztyn voievodship, despite the protests of residents of the former Elblag voievodship, Zulawy of Elblag were joined, although they are the uniform of the agricultural complex in Gdansk Zulawy. The Olsztyn province is divided into three sub-regions (Elblag, Olsztyn and Elk), 19 rural districts, 2 townships and 116 communes (16 urban, 33 rural-urban and 67 rural). In terms of the area covering 24 173.47 km²) is the fourth largest region. From the east it borders with the province of podlaskie, south - mazowieckie, west – kujawsko-pomorskie and pomorskie, from the north with Russia (Kaliningrad Region). The capital of the province is Olsztyn numbering approx. 175 thousands

residents. The second largest city is Elblag, comprising 100 thousands residents. Economic opportunities and directions of the development, determine the specificity of geographical location, link with the former eastern part of Prussia and the sea. The region is one of the three that has access to the sea and the only border with the Kaliningrad Oblast. Along the border are 8 border crossings (3 road, 3 railway and 2 marine). This localization allows for the development of infrastructure that allows for the exchange of the trade and tourism between the Poland, Russia and the Baltic countries. Border crossings are equipped with standard and wide lanes, occurring in the area of Russia and the former republics. Province is located within two Euroregions: Baltic Eurogion and the Lyna-Bench Euroregion.

2.2. Materials and methods of research

Materials were consisted of data from the Central Statistical Office, the Institute of Tourism and the Ministry of Sport and Tourism. The materials involved the high traffic of tourists in the various provinces of the country in 2008-2013. The research methodology was based on a comparative analysis of the collected data. Additionally, in order to implement posed in the work of the research, a diagnostic survey among students of economics at the University of Warmia and Mazury in Olsztyn was compiled. The survey was prepared on the basis of a questionnaire study.

3. Our own research

3.1. The development of tourism industry in the region against the background of the country

The tourist industry for many years has been developing intensively. There are many instruments of financial support environmental investments for tourism, both domestic and foreign funds. In over 10 years of investment spending for the national tourism economy has been increasing more than twice (54.4%) and reached in the 2013 level of 50.4 billion zl.

According to research Activ Group made at the request of the Ministry of Sport and Tourism in 2013, 16 million tourists came to Poland, which increased the budget of a country with 4.8 billion euros. State budget revenue in total in 2013 amounted to 279.2 billion zl and were lower by more than 20.2 billion zl towards levels of income planned in the Budget in 2013, and 3.4 billion zl higher towards the spending plan in the amended Budget. Most of the foreign tourists visiting Poland were from Germany (5.3 million tourists) and Ukraine (2.1 million visitors). According to 2013 statistical data, most of the Poles travelled to Germany (2.15 million), the UK (1.2 million) and Italy (1.1 million).

The intensity of tourist travel to various regions in the 2008-2013 period, according to the research Acitv Group and the Institute of Tourism, increased steadily with the exception of the province lubuskie and kujawsko-pomorskie. Tourists most frequently visited malopolska (7.2 million), the eastern part of pomorskie (6.0 million) and mazowsze (4.7 million). This is due to the peculiarities of the capital and the region of Krakow and Gdansk with attractive coastal and mountain offers. The

least frequent tourists visited the province of opolskie (0.7 million), lubuskie (1.0 million) and podlaskie (1.4 million) (Table 1).

Warmia and Mazury is only the ninth in terms of tourist arrivals, despite the wealth of natural resources. Low interest of tourists this region may be due to poor road infrastructure and the likely insufficient promotion of the region at the national level and abroad.

Table. 1. The intensity of tourist traffic in Poland by province in 2008-2013 (million tourists)

Specification	Years					
	2008	2009	2010	2011	2012	2013
malopolskie	3,0	2,4	2,8	2,8	5,2	7,2
pomorskie	3,7	3,7	4,5	2,8	5,3	6,0
mazowieckie	4,4	3,5	3,9	3,4	5,4	4,7
dolnoslaskie	3,2	2,8	2,8	2,7	3,7	3,9
slaskie	2,4	1,8	2,6	2,5	3,3	3,4
podkarpackie	2,1	1,7	1,5	1,4	2,4	3,1
zachodnio-pomorskie	3,3	3,5	3,9	2,8	3,2	2,8
wielkopolskie	2,4	2,4	2,4	1,6	3,1	2,6
warminsko-mazurskie	2,1	2,0	2,1	1,8	2,2	2,5
lubelskie	2,1	1,7	1,3	1,8	1,7	2,2
kujawsko-pomorskie	2,2	1,8	1,6	1,6	2,3	2,1
lodzkie	0,9	1,2	1,4	1,2	1,4	1,7
swietokrzyskie	1,1	0,9	1,3	1,0	1,2	1,7
podlaskie	0,8	0,8	1,4	1,5	0,9	1,4
lubuskie	1,4	0,9	1,0	0,8	1,0	1,0
opolskie	0,6	0,7	0,5	0,4	0,5	0,7

Source: Study of Diana Jaworowska on the basis of Activ Group and Research Institute of Tourism

3.2. Analysis of the results of survey

Respondents came from the five provinces, mainly from the warminsko-mazurskie (90 persons) and the neighboring provinces: podlaskie and mazowieckie (by 27 persons), kujawsko-pomorskie (5 persons) and podkarpackie (1 person). Among the subjects were 95 women and 55 men. The vast majority came from the countryside. According to 57% of the surveyed region of Warmia and Mazury is not sufficiently developed economically. 34.00% positive ratings. 9.00% did not give the response. 93.00% of respondents claimed that tourism has a significant impact on the economic development of the region. For the question of the most important tourist attractions of the region, more than half of the respondents (59%) indicated the nature, landscape and lake, 10% indicated architectural monuments and shrines, 9% - shopping centers and cultural events, 7% - indicated sports facilities, and only 6 % - cultural heritage, folk art, customs, traditions (Figure 1).

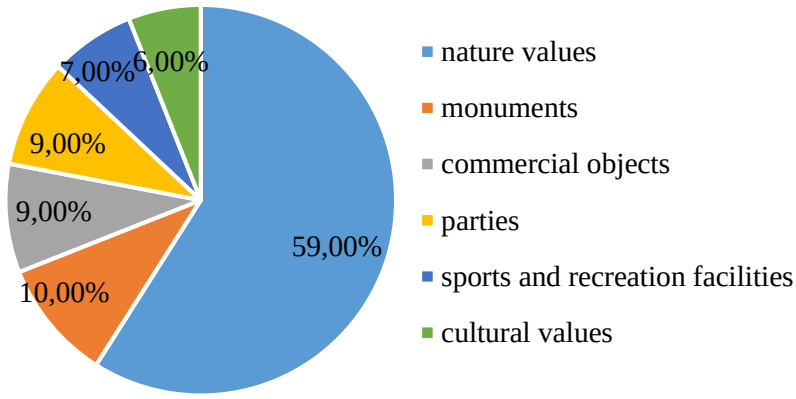


Figure 1. Tourist attractions of the region which are the main themes of migration take tourism (%)

Source: Study of Diana Jaworowska on the basis of the survey

Among the monuments of architecture and technology, mentioned Elblag Canal, Teutonic Castle in Ketrzyn, Old Town in Olsztyn, in the Sanctuary of Our Lady of the Holy Lipka.

To the most interesting cultural events pointed out: Juwenalia in Olsztyn (Kortowiada), Reggae Festival in Ostroda, Mazury Hip-Hop Festival in Gizycko, Artistic Summer in Olsztyn and Mazury Gala Dance Music - DISCO POD ,,ZAGLAMI'' in Mragowo. Less popular were Seven Music & More Festival in Wegorzewo and Sea Songs Festival in Gizycko. 1/5 of respondents did not participate in any events, 6 people chose local events such as Disco Polo Ostroda, Mazury Night Cabaret in Mragowo, Days and Nights in Szczytno and Days of Ostroleka (Figure 2).

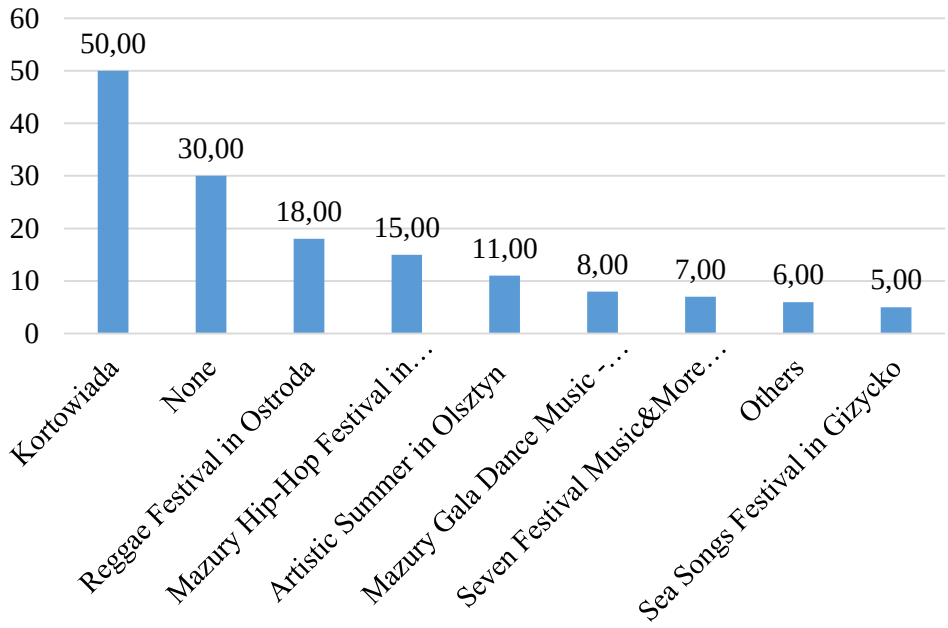
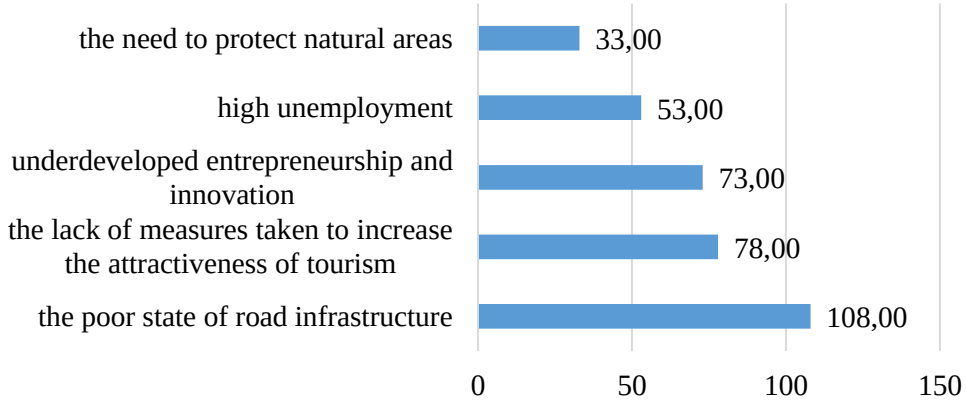


Figure 2. Respondents Participating in cultural events in the warminsko-mazurskie voivodship

Source: Study of Diana Jaworowska on the basis of the survey

According to the respondents, there are many barriers that hinder the development of tourism. The main obstacle identified was the poor state of road infrastructure, the lack of measures to increase the attractiveness of tourism, underdeveloped entrepreneurship and low innovation. 1/3 of the respondents pointed to high unemployment (Figure 3).



* Results do not add up to 100% because each respondent could indicate up to 3 barriers

Figure 3. The most important barriers to the development of tourism in the region

Source: Study of Diana Jaworowska on the basis of a survey

On the research question, why in spite of the richness of nature, the region does not enjoy a satisfactory interest of tourists, not received clear answers. The problem requires further in-depth research. Respondents indicated a number of obstacles and difficulties such as protected areas being a possible obstacle to the expansion of roads, bad weather, low air temperature during the year. An example of Dubai shows that having huge financial resources and a hot climate is not necessarily an obstacle for even in the desert they have built snow-capped mountains and tranquil gardens and the entire infrastructure. For the region an important limitation is the

inadequate state of road and railway infrastructure belongs to the least developed in the country. There is also no airport. The region is sparsely populated (living here approx. 1,446 million people, i.e. 60 people / km² (in 1437 people / km², while in the countryside 25 persons / km²)). Warmia and Mazury has one of the highest rates of natural increase and net migration (approx. -2). this demonstrates the strong ties of local people with a place to live and the region.

Despite high unemployment in recent years, the population was only slightly reduced [9]. The regional development strategy until 2025, the development of tourism and related to this field of environmental protection have been included in all three strategic priorities and operational purposes. As part of a competitive economy assumes growth potential of tourism and in other purposes: improving the quality and environmental protection and environmental monitoring.

4. Conclusions

1. Tourism is undoubtedly one of the most important and rapidly growing sectors of the economy.
2. Tourism is an opportunity for the development of regions, especially the warminsko-mazurskie voivodship, so futher actions should be undertaken, which are e.g. improving the quality of the services, any kind of financing or marketing.

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Attachment:

Survey

1. Which of the following tourist attractions are the main motive of engaging the tourist migration in your opinion? (Please rank from 1 - least important to most important - 6).
   - natural values (eg. landscape, lakes)
   - cultural values (eg. folk art, customs)
   - commercial objects (eg. shopping centers, retail stores)
   - sports and recreation facilities (eg. swimming pools, tennis courts)
   - monuments (eg. architecture, religious)
   - parties (eg. cultural, sports)
2. In which of these cultural events preferably do you participate?
   - Reggae festival in Ostroda
   - Mazury Hip-Hop Festival in Gizycko

- Mazury Gala Dance Music - DISCO POD " ZAGLAMI " in Mragowo
- Sea Songs Festival in Gizycko
- Seven Music & More Festival in Węgorzewo
- Artistic Summer in Olsztyn
- other (please specify)…..
- none

3. Please select according to you, the main barriers that inhibit the development of tourism in the region (up to 3).
   - the poor state of road infrastructure
   - the need to protect natural areas
   - high unemployment
   - underdeveloped entrepreneurship and innovation
   - the lack of measures taken to increase the attractiveness of tourism
   - other (please specify)….

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The idea of sustainable development and its evolution in agricultural policy: The case of changes in agri-environmental programmes

Key words: *sustainable development, agriculture, rural areas, environment*

Summary: The idea of sustainable development emerged over 50 years ago to protect the natural environment, eradicate poverty and improve life quality. Published in 1969, the first UN report on threats to the natural environment and security of future generations appealed to the international community to achieve sustainable development. The first UN Conference on the Human Environment was held in Stockholm in 1972, producing the definition and principles of sustainable development. In the 1990s, the EEC introduced the idea of sustainable development to its agricultural policy, while Earth Summits allowed for a global discussion on human security threats posed by water shortages, environmental pollution and climate changes generated by industry and farming. The resulting arrangements made globally paved the way for introducing agri-environmental programmes and pro-environmental support schemes to agricultural policies world-wide. Poland began their implementation after accession to the EU. The idea of sustainable development was also included in Polish national and regional development strategies, although it was the current Rural Development Programme 2014–2020 that brought specific tasks for the country. They cover 7 priorities and 30 variants for sustainable agriculture and common environment preservation in agricultural farms. This work analyses changes in agricultural policy based on the evolution of the idea of sustainable development and agri-environmental programmes.

1. Introduction

The concept of sustainable development covers multiple areas of human activity related to the natural environment and farming. Proponents of intensive economic development, who also called for using the latest advances in science and technology for unlimited exploitation of natural resources, eventually met with strong opposition from those who objected to their appropriation of the environment. Mounting concern over the state of the natural environment and the security of future generations gave rise to a wide-ranging discussion, leading to goals and strategies being developed for attaining sustainable development. These were deemed necessary to guarantee economic growth and high food quality while causing no damage to the natural environment. It took years to set out principles for sustainable agriculture and management of natural resources. The regulations governing organic farming, which currently receives EU financing in Poland, were adopted by the European Union in 2007.

The discussion that accompanied the process of developing these regulations covered an array of aspects, starting with the idea to first meet the current demands of society without damaging the environment and thus also the possibility to meet the needs of future generations [1]. The notion of sustainable agriculture appeared in many contexts, relating to the notion of social development as such, as well as to preserving the natural capital, managing farming space, protecting the natural environment, safeguarding biological diversity, and mitigating the consequences of human activities. As well as being introduced to the Common Agricultural Policy (CAP), the National Development Strategy for 2020 and the Regional Development Strategy, the principles of sustainable agriculture have also

been given a role in the new agricultural direct payments scheme, as set out in Rural Development Programme (RDP) 2014–2020 [2]. The Programme introduces an obligation to protect the environment, soils and water, prohibits the use of harmful pesticides and calls for scientifically-controlled reduction of fertilisation levels. Moreover, it creates new obligations for farmers, including organisational, financial as well as mental ones, with the latter intended to promote a new way of thinking about preserving the environment and natural resources for future generations. As well as exploring the changes introduced by RDP 2014–2020 to the EU agricultural policy and the rules for receiving payments for nature conservation, this work also analyses the threats of non-compliance.

2. The origin and definition of sustainable growth

2.1. Origin

Sustainable growth as a notion of a broadly-defined economic growth accompanied by environmental preservation emerged over half a century ago and was triggered by air and water pollution as well as by a worsening energy crisis, which made the public aware of the need to change the way global natural resources were used. The first Intergovernmental Conference of Experts on the interrelationships between the environment and development was held by UNSECO in 1968, resulting in the launch of the Man and the Biosphere Programme, the first of its kind. The programme laid out the principles for fulfilling the developmental needs of the human kind while also taking account of the needs of future generations.

The term "sustainable growth" was also used in the 1969 UN report that warned of an alarming state of the natural environment. The then Secretary-General of the United Nations called for developing a global concept of environmental protection and launching international cooperation dedicated to that end. Furthermore, sustainable growth was also linked to protecting the natural environment in the 1969 goals and work programme of the International Union for Conservation of Nature. Although this is the date commonly agreed as the birth of "sustainable growth", it was only three years later that the issue of environmental protection and the UN report received the attention they deserved, during the UN Stockholm Conference held in 1972. This was the first major event allowing for the mounting concern to be voiced over the depletion of natural resources and the deterioration of the natural environment, leading to the conclusion that increased measures were needed to prevent the environmental threats at their source.

3. Definition

Although the term "sustainable growth" was first given the meaning it continues to have today in "The Limits to Growth", a 1972 report by the Club of Rome, its definition was established at the 1972 UN Conference on the Human Environment, where "sustainable growth" was defined as: *"economic development that is conducted without depletion of natural resources".* This definition was subsequently developed to achieve the form adopted by the World Commission on Environment and Development, also known as the Brundtland Commission, in a report entitled "Our Common Future" (1987). It defined "sustainable growth" as: "*development that meets the needs and aspirations of the present*

without compromising the ability of future generations to meet their own needs" [3].

This new definition covered a host of different aspects, ranging from human population and the world of fauna and flora to ecosystems, air and water, and natural and energy resources. Defined with a view to benefiting future generations, this vision of development adopts a comprehensive and integrated perspective on the problems and needs of the human kind. It also served as a basis for numerous interpretations and elaborations created in the years to come that proved necessary to specify the principles for attaining sustainable growth in particular directions and measures of agricultural policy, while also considering particular environmental and economic conditions. Based on the Burdtland definition, Kiełczewski identified two main goals of sustainable growth:

- "*equity within generations', which calls for reducing developmental disproportions between highly-developed and underdeveloped areas, striving to meet people's basic needs and eradicating poverty, while also fostering the cultural diversity and entrepreneurship of societies;*
- and *'equality between generations', which is understood as the necessity to preserve the natural capital for future generations by an economical use of natural resources, preserving a dynamic balance in the natural environment, and respecting the traditional indicators of economic growth: the appropriate relationship between consumption and investment, as well as maintaining demographic sustainability."* [3].

According to Rakoczy, [4] the principle of intergenerational equity is far from seeing it necessary to abandon the exploitation of the environment for the sake of future generations, instead promoting a rational use of the natural resources available. Under this interpretation, the main

goal of sustainable growth is to look for and utilise alternative sources of raw materials and energy.

4. Historical background

4.1. Measures for sustainable development taken globally

Neither the 1969 UN report and the organisation's call for launching international cooperation nor the 1972 Stockholm Conference managed to formulate specific principles for global environmental protection. Likewise, neither managed to solve the problem of economic underdevelopment of the poorer countries or to limit the economic growth taking place under the conditions of non-compliance with environmental protection standards [5]. In contrast, the Stockholm Conference did lead to launching several initiatives for the protection of the environment, making the need to develop a set of principles linking economic growth with nature preservation the subject of subsequent international conferences and conventions. Thus, it also became an important element in building development strategies both nationally and regionally. This further contributed to the creation of a number of organisations responsible for preserving the environment and its resources.

A series of international events for raising awareness of environmental protection and sustainable growth were organised, which led to the adoption of specific regulations, restrictions and obligations concerning environmental protection. The most important such documents include:

– the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973), also known as the Washington Convention;
– the Convention on Fishing and Conservation of the Living Resources in the Baltic Sea and the Belts (1973), also known as the Gdańsk Convention; and
– the Convention on the Protection of the Marine Environment of the Baltic Sea Area (1974), also known as the Helsinki Convention, which is governed by the Baltic Marine Environment Protection Commission (HELCOM). The main responsibility of the latter body is to protect the marine environment of the Baltic Sea from pollution and prepare recommendations for the contracting states, which then implement them into their domestic legal systems. A new Convention on

the Protection of the Marine Environment of the Baltic Sea Area was signed in 1999.

The defining moment for the concept of sustainable growth came with the adoption of the first global convention on preserving the environment: The World Conservation Strategy of 1980, marking the beginning of the global environmental policy. The Strategy was prepared by the International Union for Conservation of Nature and Natural Resources (currently: the International Union for Conservation of Nature; IUCN) in cooperation with the United Nations Environment Programme (UNEP) and the World Wildlife Fund (WWF), and in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

The aim of the World Conservation Strategy was to achieve three main objectives of living resource conservation, namely:

– maintaining essential ecological processes and life-support systems;
– preserving genetic diversity;
– ensuring the sustainable utilisation of species and ecosystems.

The Strategy also identified the following priorities:

– reserving good cropland for crops;
– preventing agriculture from expanding to areas with a protective function, such as forests;
– introducing principles for healthy food production.

Prepared by the IUCN and the UNEP, the World Charter for Nature was adopted by UN member nation-states in 1982, which recognises the unity of human beings and their environment, and calls for its protection. Although they are still binding, the provisions laid down in the Charter have yet to receive specific implementing acts.

5. International rural development measures

The principle of sustainable rural development was laid down at the 1991 World Health Organisaion (WHO) Conference in the Netherlands and subsequently developed in Agenda 21, one of the key documents on sustainable development. It was developed at the Earth Summit, which was held in Rio de Janeiro in 1992 gathering representatives of 172 countries, including Poland, and 2,400 non-governmental organisations (NGOs). All of the participating states became signatories to the document, which contains the following statements and conclusions:

"Humanity stands at a defining moment in history. We are confronted with a perpetuation of disparities between and within nations,

a worsening of poverty, hunger, ill health and illiteracy, and the continuing deterioration of the ecosystems on which we depend for our well-being."

"This programme demands new ways of investing in the future to reach global sustainable development in the twenty-first century. Its recommendations range from new ways to educate, to new ways to care for natural resources, and new ways to participate in designing sustainable economy. The overall ambition of Agenda 21 is to create a safe and just world in which all life has dignity and is celebrated."

Ten years later another Earth Summit was held in Johannesburg, attended by 22,000 participants, 10,000 representatives from 193 countries and 8,000 representatives of various non-governmental institutions. Dedicated mainly to tackling the problem of clean water shortage, the event also brought significant decisions regarding the reduction of greenhouse gas emissions, setting the reduction rate at the level of 5.2% by 2012.

The idea of sustainable farming developed in a number of directions and priorities, leading to an agricultural policy being worked out that provides increasing funds for the preservation of the environment and sustainable rural development.

6. Sustainable agriculture and rural development

6.1. Definition of sustainable agriculture

The definition of sustainable agriculture and rural development is a broad one, encompassing all elements related to rural areas, spatial development and landscape, natural and cultural heritage, and all sections of agricultural production. It pertains to the whole of the economy of a given region. According to Woś, it is "a modern conception of shaping

the internal balance of agri-business and its relationships with the environment", [6] one that aims to generate economic profit while closely related to preserving natural resources and ensuring their reproducibility.

The issue of environmental protection in agriculture found its way to the EU's CAP as late as the 1990s, when agriculture was taking up to 60% of the European Economic Community's budget.

5.2. Reform of the agricultural policy

The beginning of the agricultural reform came with the 1985 adoption of a "Green Paper", which provided for new instruments of financial aid for farmers and new measures for the protection of the environment, including subsidising the set-aside of arable land and afforestation, and supporting areas of natural significance. The farm was assigned a double role consisting of both production and protection of the surrounding environment.

Another groundbreaking reform of the European agricultural policy was the one introduced in 1992 by Ray MacSharry, the European Commissioner for Agriculture. As well as extending the impact of agricultural production, the reform also took account of its social functions and acknowledged the need for a fairer distribution of income from agriculture, which was now to be spent to a greater extent on the protection of the environment and rural development [9]. With the implementation of MacSharry's reform, environmental protection has become an integral component of the CAP.

Further changes were introduced to the policy by the 2003 reform agreed on in Luxembourg, also known as the Fischler Reform, which set out a new direction for rural development by providing new funds

for sustainable development of rural areas and introducing a new payment programme. Under that programme, most of direct production-specific payments were replaced by a decoupled single payment scheme. The programme fostered innovation and modernisation of agriculture and forestry, promoted healthy food and encouraged improved production quality. The new payment scheme supported sustainable agriculture, as well as introducing the mechanism of cross-compliance,[10] one that linked direct payments to farmers' compliance with basic standards concerning the environment, food safety, animal and plant health and animal welfare, among other criteria.

The significance of financial aid and measures for boosting rural development, fishery protection and preservation of the environment was emphasised even further in RDP 2005–2013. The European Agricultural Fund for Rural Development (EAFRD) and the European Agricultural Guarantee Fund (EAGF) were set up as separate from the European Agricultural Guidance and Guarantee Fund and tasked with handling direct payments to farmers. After Poland's accession to the EU, environmental efforts in agriculture were included in RDP 2004–2006, a programme with a budget of 3.6 billion zloty, 80% of which was EU funded. The funding was mainly spent on agri-environmental programmes, ecological farms, strengthening the condition of farms and on afforestation subsidies. A significant change was introduced with payments for farms in less favoured areas, a direction of financial aid that has been preserved to this date. The new financial perspective for 2007–2015 made resources devoted to environmental protection independent from the support provided for this purpose in agri-environmental programmes, dividing them between two key operational programmes: Infrastructure and Environment Programme

and Regional Operational Programme. The tasks financed by means of these programmes, which are now approaching completion, were meant as a continuation to those set out in the previous programme period. In contrast, the new RDP for 2014–2020 introduces considerable changes to the environment and nature preservation programmes.

7. State of agriculture in Poland

The Polish agricultural industry is ranked 7th in the EU, making up 5.8% of EU's total agricultural output. At 106 billion zloty, Poland's total agricultural output in 2014 was slightly lower than a year before. It was the result of a 5.8% decrease in crop output, which reached 54.4 billion zloty, with a simultaneous increase of 3.6% in animal output, at 51.6 billion zloty. A rise in animal output was observed in all sections of pig meat, eggs and milk production. Poland is ranked third, exceeded only by the Netherlands and France, in poultry meat export outside the European market, although it is the European leader in the production apples, blackcurrant and mushrooms, and is only exceeded by China in the production of concentrated apple juice globally. The value added in the entire agricultural sector, farming, forestry, fishery and hunt reached 52 billion zloty in 2014 (on the basis of the selling prices), the highest value since Poland's accession to the EU.

Data provided by the Central Statistical Office and the Ministry of Agriculture and Rural Development shows that total farmland area in Poland covered 16.3 million ha in 2014, a minor decrease of 1.1% compared to 2013. Approximately 1.5 million agricultural farms take up 14.6 million ha of agricultural area, with around 90.9% of them being privately-owned and, in a majority of cases, covering an area under 5 ha.

In 2014, over half the farms in Poland took up under 5 ha of agricultural area, while as many as three-quarters of them covered an area under 10 ha. The concentration of agricultural area is progressing slowly, which is why rural development strategies need to take account of the barriers that result from the fragmented nature of agricultural farms. These are usually run using traditional methods and low levels of fertilizers, plant protection products and industrial feedstuffs.

It is estimated that roughly a quarter of Poland's total land area is farmed in a way allowing for preserving biodiversity. This also applies to rural areas and extensive agricultural production farms as well as unproductive parts of agricultural area, such as field baulks, tree clusters, shrubs, wetlands and small ponds. Overall, Poland is a country of rich natural and climatic diversity, making for favourable conditions of life for animals, herbs, weed and wild-type plants. By and large, animals find their refuge flocking to meadows, pastures, ponds and forests.

8. Strategy for sustainable agriculture and rural development in Poland

The concept of sustainable agriculture and rural development in Poland is provided for in *Strategy for sustainable development of rural areas, agriculture and fishery for 2012–2020* [12]. The Strategy entered into force in November 2012, having been approved by the Minister of Regional Development as compliant with the Medium-term Country Development Strategy by 2020 and its primary goal of "active society, competitive economy and efficient state". The strategy defines the strategic goal for rural areas as: *improving the quality of life in rural areas while effectively utilising their resources and potential, including agriculture and*

fishery, with a view to fostering sustainable development of the country [2]. This goal is to be achieved through:

1. Improving the quality of human and social capital, employment and entrepreneurship in rural areas;
2. Improving the quality of life in rural areas and their spatial accessibility;
3. Ensuring food security;
4. Improving the productivity and competitiveness of the agri-food sector; and
5. Preserving the environment and adapting to climate changes in rural areas.

Covering all the directions of development for rural areas, agriculture and fishery, the Strategy 2014–2020 also takes accounts of a range of civilisational challenges, including the ageing society, climate change, development of informational technologies as well as professional and territorial mobility. The level of EU funding for implementing the strategy remains unchanged, at 34.5 billion euro, an amount Poland received in the first funding period where the sum total was divided as follows: 18.1 billion euro was spent on direct payments, 14.3 billion euro – on rural development, and the remainder – on market measures. Overall, around 119 billion zloty was spent in Poland on direct payments between 2004 and 2014, from both the EU budget and national budget, catering for about 1.4 million farmers with 1 ha of land. This translates to roughly 14 million ha covered by the payments. Starting from 2015, the 1 ha requirement no longer holds, making each farmer breeding animals entitled to financial aid as long as the payment exceeds 200 euro in worth.

The RDP is implemented in Poland under the Act of 20 February 2015 on supporting rural development using the funding of the European

Agricultural Fund for Rural Development within the Rural Development Programme for 2014–2020.[2] Pursuant to Article 45(1)(1) and Article 45(2) of the Act, the Polish Minister of Agriculture and Rural Development issued Regulation dated 13 March 2015 on the subject of detailed conditions and procedures of granting and the pay-out of financial assistance under the "Organic Farming" action plan [13] within RDP 2014–2020. The responsibility for completing the plan was assigned to the Agency for Restructuring and Modernisation of Agriculture, while managing the rural development funds was entrusted to the Offices of Province Marshals. The present analysis concerns the changes introduced to agri-environmental programmes in the current funding period, including a host of new pro-environmental measures that farmers have already recognised as overly complicated. An obligation was imposed on farmers to couple their farming practices with the preservation of the environment. The task of working out the guidelines and procedures for particular sections of agriculture was given to the scientific institutes of leading Polish universities.

The Ministry of Agriculture and Rural Development commissioned four development and research programmes to be drawn up for 2016–2020, covering the broad scope of plant and animal husbandry, genetics, food security, plant protection, experimenting and agrotechnology. The subject matter of the programmes was specified in four resolutions of the Council of Ministers adopted on 15 December 2015, [14–17] and the budget provided for their completion exceeded 150 million zloty. One of Poland's leading institutes with a long-standing expertise in sustainable rural development is the Institute of Soil Science and Plant Cultivation – State Research Institute in Puławy.

The research centres were tasked with drawing up practical rules and guidelines for farmers to help them meet the requirements of the integrated plant production and protection that are set out in the current RDP 2014–2020. The programme's new pro-environmental measures come with a host of requirements and obligations related in particular to examining the farmed environment, examining the nitrate content of soil and water, examining the humus content of the soil, preparing wildlife inventory and monitoring climate change.

9. Directions of pro-environmental measures in agriculture

The payment scheme within RDP 2014–2020 provides for 7 directions of pro-environmental measures, with several variants of each agri-environmental package and detailed conditions pertaining to agrotechnology, maintenance work and deadlines for its completion:

Package 1. Organic farming

Package 2. Valuable habitats and endangered bird species in Natura 2000 areas

Package 3. Valuable areas outside of Natura 2000 areas

Package 4. Preservation of endangered genetic plant resources in agriculture

Package 5. Preservation of endangered animal genetic resources in agriculture

Package 6. Protection of soil and water

Package 7. Buffer zones and field baulks

The programme is aimed to support modern, sustainable methods of agricultural production, protect agricultural areas of natural significance and preserve plant and animal biodiversity. Organic, sustainable farming

is divided into four agri-environmental variants: agricultural cultivation, vegetable cultivation, horticultural and berry cultivation, and feed cultivation. Receiving financial aid is made conditional upon the farmer's voluntary commitment to take up and maintain for 5 years one type of measure and agri-environmental or organic farming variant, as provided for in Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products (OJ L 189, 20.7.2007, as amended)[18] and in Commission Regulation (EC) No. 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No. 834/2007.[19] The rules for implementing and funding organic farming in Poland are regulated by the Act of 5 December 2014 (Journal of Laws of 2015, item 55) amending the Act on organic farming, and three 2010 Regulations of the Minister of Agriculture and Rural Development: Regulation dated 18 March 2010 (Journal of Laws No. 56, item 348); Regulation dated 12 May 2010 (Journal of Laws No. 94, item 607); and Regulation dated 10 November 2010 (Journal of Laws No. 225, item 1468) on the subject of detailed conditions of delivering organic farming and supervision thereof, and on the certification of organic farming inspectors. There are detailed conditions and procedures of granting financial assistance under the "Agriculture-Environment-Climate" action plan within RDP 2014–2020, which are laid down in the Regulation of the Minister of Agriculture and Rural Development dated 18 March 2015 (Journal of Laws, item 415).

The Organic Farming package introduces a number of new requirements, including the one to carry out extended soil analyses. Formerly, soil analysis involved the requirement to indicate soil reaction and the content of assimilable potassium and magnesium, as well

as assessing the need for liming. This has now been extended by the examination of the humus content of the soil in areas covered by the programme. Such an examination is to be carried out at both the beginning of the programme and after it has been completed. By means of Regulation dated 28 April 2015 (Journal of Laws, item 676) on the subject of data provided by soil analysis results, the Minister of Agriculture and Rural Development published a list of official and reference laboratories. Another condition for financing sustainable development is appropriate crop rotation and plant selection (at least three crop groups for the five years of the programme) as well as reducing fertilisation.

By joining the programme, the farmers commit themselves to using only natural soil conditioning measures, such as spreading manure, ploughing the straw and using a catch crop, to conducting them in a timely manner, and to keeping a record of agrotechnical operations performed. The total share of the main crop and cereals should not exceed 65%, while each of the remaining crops should take no less than 10% of total arable land. When implemented correctly, a 5-year-long implementation of this strict and work-consuming programme based on balanced fertilisation and introducing organic matter to the soil should lead to increased humus content, as confirmed by soil analysis. Failure to meet any of these requirements or agrotechnical deadlines results in the withdrawal of the financial aid and the need for the farmers to return the funds they have already received.

All the remaining packages are closely related to protecting the environment, water and soil, preserving endangered animal species and introducing the greening of agricultural areas. Agri-environmental variants and packages may be combined. Failure to meet any of the conditions

or other irregularities result in the farmer having all their area payments decreased in a given year. Moreover, the programme introduces more stringent requirements as regards doses, time and means of fertilisation, in particular in steeply sloping areas, bogs, areas covered by water or snow, and those near water courses, as well as tightening the conditions for storing natural fertilisers and dealing with leachate.

9.1. Obligation to green arable land

A new obligation introduced by the RDP requires agricultural farms with an area of over 10 ha to green arable land, allocating to that purpose 5% of their arable land, and starting from 2017 – up to 7%. The greening obligation covers three practices: crop diversification, maintenance of permanent pasture or maintenance of ecological focus areas (EFA). Crop diversification requires farms with 10–30 ha of land to keep two different crops, while farms in excess of 30 ha of land are required to keep at least three different crops, as well as meeting percentage requirements for each crop.

Another greening practice is the maintenance of permanent pastures. Under an EU agreement, farmers are required to maintain unchanged permanent pasture area at national level, and to maintain valuable areas in Natura 2000 areas in an unchanged form, which means they may not be converted or ploughed.

The third greening practice is the designation of EFAs, a requirement imposed on farms with over 15 ha of arable land. The programme provides a detailed specification on how to designate such areas. According to the EU, EFAs also include set-aside land, landscape elements, agro-forestry systems, catch crops or the green cover. Moreover,

the following are also recognised as EFAs: nitrogen-fixing crops, areas adjacent to coppice and parcels adjacent to a forest, as well as other areas not utilised in agricultural production that receive no mineral fertilisation or plant protection treatment. It is left to member states to decide which of these forms to choose and implement into national support programmes.

10. Discussion

It took many years for the Polish agricultural policy to adopt the idea of sustainable development along with the implementing provisions, working out the principles and conditions for payments to be delivered under the current RDP 2014–2020 for sustainable agriculture, as well as developing the related principles of sustainable plant protection and fertilisation and the common conditions imposed on farmers to protect the natural environment. Analysis of relevant documents, European regulations and Polish implementing provisions demonstrate that the implementation of sustainable development was not a dynamic one. There also appears to be a paucity of result data that would allow the researcher to measure and assess the value of EU-funded environmental changes made so far. Furthermore, analysis of Council Regulation (EC) No 834/2007 and RDP 2014–2020 documentation show the present programme to be the first to address sustainable agriculture in a comprehensive way.

However, it also indicates the conditions set out for the implementation of the programme might prove unreasonably high, as it lays down particularly strict and complicated criteria for farmers to receive financial support, demanding them to master agrotechnical principles and conduct chemical, maintenance and environmental research

they have never been expected to perform before. This puts into question the feasibility of meeting the multi-directional aims of the programme, even more so that the Polish Ministry of Agriculture waited with commissioning the RDP 2014–2020 methods and practices to be drawn up until as late as December 2015 [12].

Most serious questions can be raised with respect to completing the programme's entire environmental protection segment, which assumes the implementation of 7 priorities and a total of 30 agri-environmental variants. To be implemented, each of these variants requires each agricultural parcel covered by one of the above mentioned practices to be environmentally assessed, as lack of such assessment is the main cause for biodiversity loss. As is demonstrated by Central Statistical Office's 2014 structural data on agricultural farms, [11] there are in excess of 400,000 farmers who meet the area criterion of having over 10 ha of land and utilise multiple parcels within a single farm. It follows that the environmental assessment requirement concerns at least several million agricultural parcels, which are to be monitored throughout the entire duration of the programme, making it well-nigh impossible to produce such a vast range of documentation and monitoring within a single year. During the 2015 application period, the programme fund management institution had no necessary instruments at its disposal, such as programmes, guidelines or specialist personnel dedicated to cooperation with farmers with respect to particular agri-environmental variants.

11. Conclusions

First, Poland is a country of diversified natural habitats, attractive landscape and advantageous agricultural farm structure, making for

favourable conditions for implementing a common environmental protection programme in agriculture. Second, farmers operating small farms find it difficult, if not altogether impossible, to environmentally assess areas with particularly attractive natural environment and to observe the requirement for performing chemical soil analysis, control fertilisation and monitor water pollution. Third, wildlife inventory of agricultural farms is in short supply, hindering the implementation of measures for the protection of the environment, field baulks, wild plants and old, traditional plant and tree varieties. This, in turn, may render it difficult to implement the EU arrangements demanding 5%, and starting from 2017 – 7% of arable land to be allocated for the greening procedures. Finally, to meet the requirements of soil protection and biodiversity preservation, the existing network of research services must be expanded to make it easier for farmers to have chemical soil analysis and environmental research conducted on their land.

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Agri-environmental programmes as a chance for the revitalisation of forgotten apple tree varieties

Keywords: *EU funds, traditional apple tree varieties, revitalisation*

Summary: Taxonomically speaking, the apple tree belongs to the *Rosales* order of the *Rosaceae* family. It is the most often cultivated fruit plant in Poland. Particular apple tree varieties differ in terms of fertility, disease resistance, as well as taste qualities. Traditional apple tree varieties are characterised by strong resistance to frost and disease. Their weaknesses, on the other hand, include alternate bearing and their less-than-ideal capacity for long-term storage. Although high-yielding varieties are prevalent on the market, we can observe a growing interest in the cultivation of traditional varieties. A key factor in the long process of their reconstruction is the funds available to fruit producers within agri-environmental programmes. The aim of this paper is to demonstrate how these funds are deployed for the purpose of reconstructing traditional apple tree varieties.

1. Introduction

The cultivation of apple trees in Poland is highly advanced, both at the amateur and at the commercial level. All currently cultivated varieties come from wild, small-fruited forest trees. Apple tree varieties were refined into premium varieties by humans as a result of vegetative propagation and selection. The first premium apple tree varieties came to Poland from Turkey and the Caucasus, where wild apple trees can sometimes still be spotted. Although it was initially believed that apples could only

be consumed dried, the aroma and taste qualities of freshly harvested fruit were soon appreciated as well [1,2]. In Poland, apples were first found at the archaeological site in Biskupiec, dated to 800 BC. The first apple orchards appeared in monastic and palace gardens. As a fruit plant, the apple tree has a very long history. The first charred remainders of apple trees were excavated in Turkey and date back to over 6,500 BC. When it comes to Europe, it is estimated that the first apple seeds reached its territory about 4,500 BC. The cultivation of the new premium varieties meant that trees – especially those exported into slightly colder countries – had to be acclimatised. However, this process did not always have the desired effect, as apple trees grown in a region with climatic conditions unfavourable to their development often bore fruit of lower taste qualities. As a result of unsuccessful acclimatisation, it proved necessary to cultivate indigenous apple varieties in many different countries [2,3].

The intensive development of fruit farming in Europe and America influenced the later changes that took place in Poland as well. In the interwar period, many varieties were imported from America, France and Russia. This was also the time when the slogan "an orchard on each farm" began to be promoted. The aim of that campaign was to improve the profitability of small farms. Moreover, as time went by, the number of academic publications and various types of popular guidebooks available to fruit producers in Poland began to increase. In 1929, many of the varieties cultivated in Poland at that time were destroyed by extreme frost. Some of them were successfully recreated but ten years later another frost struck, leading to the decline of premium varieties. The outbreak of World War II prevented another revitalization of these varieties, for which reason an intense reconstruction of Polish fruit farming began only

after 1945. A key figure in the post-war history of Polish fruit farming was Professor Szczepan Pieniążek, a great scientist, cultivator and orchard lover. His long-term work and commitment contributed to the apple's becoming the most commonly produced fruit in Poland. The popularity of apples results from the long process of introducing more fertile, easily storable varieties into production. In the period of socialism, new varieties were selected not only on the basis of their fertility but also depending on whether their ripening period was convenient for fruit producers. Equally important at the time was the tree form, which determined the ease of harvesting and cultivating. The then propagated principle was to produce as much and sell as thriftily as possible. As a result, traditional varieties of apple and other fruit trees fell into oblivion. Poland's accession to the EU in 2004 led to the gradual development of ecological farming and to the implementation of the idea of sustainable use of natural resources. The latter has contributed to the ever more widespread ecological education of the society. An increased interest in organic products has initiated the return to traditional varieties, characterised by unique taste. Moreover, old fruit trees are currently believed to be a crucial element of Polish cultural heritage. Due to their strong disease-resistance, over half-century old trees can still be spotted in the Polish countryside, where they function as an important part of local landscape and history.

This paper is a review aiming to present the current level of extinction risk faced by traditional apple tree varieties, as well as to point to the possibilities of their revitalisation using EU funds.

1.1. The origins of the apple tree as a fruit plant

From the point of view of taxonomy, the apple tree *Malus* belongs to the pome fruit subfamily *pomoideae* of the rose family *rosacea* [4,5]. According to Rejman (1994), due to the species' susceptibility to cross-breeding, a comprehensive taxonomy of the apple tree is yet to be prepared. The genus *Malus* is divided into five sections. The first section, *Eumalus* Zabel, includes true apples, whose characteristic feature is simple leaves. The second section – *Sorbomalus* Zabel includes trees with small fruit and lobed leaves. The third section – *Chloromeles* Rehder comprises trees whose fruit are usually large and inedible. The fourth section includes only one species, which is of Asian origin – *M. trilobata.* The fifth section, *Docyniopsis*, is comprised of the wild species which had no influence on the development of cultivated apple tree varieties [6]. Over twenty various species of the apple tree are currently known, most of which come from China, the Caucasus, South East Europe and Central Asia. Two species were particularly important in the aforementioned process of developing premium apple tree varieties: *Malus pumila* – paradise apple – and *Malus sylvestris* – the European crab apple. The former is distinguished by a specific shrub, which can reach up to four meters [6,7]. *M. sylvestris*, in turn, is characterised by its impressive over height reaching up to over ten meters. An Asian mountain species, *Malus paradisiaca*, is also believed to have played an important role. This is because this apple tree enabled the cultivation of dwarfing rootstocks, which have proved themselves a breakthrough in the nursery practice. With these rootstocks it is possible to grow dwarf apple trees, whose main advantage is the ease of harvesting the fruit [8,9,10].

For this reason, such trees are preferred for the cultivation in mass-producing apple orchards. A very important element of the broadly understood process of cultivating varieties with desirable qualities was the selection of varieties strongly resistant to diseases and frost. In order to achieve this, cultivators cross-bred wild species of apple trees, such as Siberian crab apple, *Malus baccata*, pear-leaved crab apple, *M. prunifolia*, and Japanese flowering crab apple, *M. floribunda*. The lifespan of the apple tree as a cultivated plant can reach up to 200 years. Given the relatively unfavourable climate in Poland – in particular: frequent heavy frost – apple trees are much more often cultivated in the country's southern provinces. However, it must also be recognised that in spite of unfavourable climate, remnants of old orchards can still be encountered in Poland that are home to over half a century old trees [10,11].

1.2. Soil-climatic conditions in the cultivation of apple trees

The proper growth of young trees in a tree nursery depends on the climatic factors, such as temperature, sunlight exposure, rainfalls and air humidity, winds, rapid temperature fluctuations and hail.

The apple tree is a temperate climate plant. The appropriate temperature for the apple tree is between 13.5 and 15.5 ºC, although some varieties need higher temperature to bare valuable fruit [1,6,8]. Regions susceptible to heavy frost in winter or insufficient warmth in summer often fail to meet the requirements of more temperature-sensitive apple tree varieties [12].

The average annual temperature in Poland oscillates between 8,5ºC in the south-west and 6 ºC in the north-east of Poland. Of particular importance for apple tree orchards are the minimum temperatures in late

autumn, winter and early spring. Excessively low temperatures can cause the freezing of trees and grafted buds, or even damage the root system. The most critical period and temperature fluctuations occur in spring. Temperature drops below 0ºC are dangerous, especially when they occur after a long period of warm weather. A rapid cooling can lead to the freezing of young shoots and ripening buds. The average temperature in January in Poland oscillates between -1ºC in Lower Silesia and -5ºC in Podlasie Province and can vary depending on the year and the severity of winter. Sometimes temperature in the winter months can sink to as low as -38ºC, which usually leads to the freezing of the overground parts of plants, especially in young orchards and tree nurseries. Proper development of trees and their yield crucially depends on the length of the vegetation period, which in Poland varies between 185 and 225 days, and the average daily temperature. The difference in the vegetation periods between the warmest and the coldest regions is 50 days. The length of the vegetation period determines when plants begin and cease to grow, the woodiness of their shoots, as well as the winter preparations of trees and shrubs. It is more profitable to start and run tree nurseries in the regions of Poland where the vegetation period is longer. In colder regions, with a shorter vegetation period, the cultivation of fully developed rootstocks or trees involves increased expenditures and sometimes also a longer production period, with an additional year devoted to root cuttings production [9,10,11,12].

The average daily temperature in Poland remains at above 5ºC. The growth of young plants largely depends on temperatures in the summer. The highest temperatures in this period can reach up to 35ºC. High temperatures accompanied by a lack of rainfall hamper the growth of young

trees in the tree nursery. Temperatures are determined by season and sunlight exposure. A good sunlight exposure guarantees proper growth and development of each plant. Availability of light influences the process of photosynthesis and the production of organic compounds out of carbon dioxide and water. Apart from the provision of the optimal temperature of approx. 20–25ºC, proper fertilisation and irrigation are necessary. Only when all these conditions are met can fully developed trees and rootstocks be grown.

Natural rainfalls and air humidity are an important feature of the climate. The deficiency of water in soil hampers the development of trees, especially at the early stage of their growth.Nursery production yields most successful results in the regions where the average annual precipitation is approximately 600 mm. The distribution of rainfalls and their intensity is very important for the development of plants in spring, as plants show an increased water demand in this period. In winter, snowfalls are advantageous to orchards. The resultant snow cover prevents the soil from freezing and protects trees with a shallow root system from damage. Moreover, the distribution of rainfalls affects the spreading of disease processes. Long rainfalls increase the frequency of fungi infections among trees. The annual rainfall distribution in Poland has a positive effect on fruit plants. Maximum rainfalls occur in two periods – in July and, to a lesser extent, in November/December [10,11].

The majority of winds in Poland are westerlies and, to a lesser extent, easterlies. The easterlies are cold in winter and dry in summer. The westerlies bring rainfalls in summer and warmer temperatures in winter. Stronger winds blow in northern Poland and in some submontane regions. Winds cause the trunks of young trees to bend and can lead to

permanent damage. Young shoots are particularly exposed to the effects of wind, which can cause their breaking [10,11].

Plants are endangered by hail, which in our climate most often occurs in June, especially in the south-east, in Świętkorzyskie, Małopolska and Lublin Provinces. Young shoots and leaves are particularly vulnerable to damage. When seriously damaged, such trees can lose their trade value. The amount of damage caused by hail and the type of injuries suffered by leaves, buds and young shoots depends on the size of hailstone [9,10].

An important element of proper cultivation of fruit tree nurseries and orchards is the provision of adequate, fertile compost and soil maintenance. Bare fallow, herbicide treated fallow and various types of mulching are used to this end. Appropriate crown formation and plant fertilisation are also important factors. The term "black fallow" refers to the soil whose cover has been removed by regular mechanical or manual weeding or through the use of herbicides, the latter being an easier and more effective solution. The maintenance of the mechanic or herbicide treated fallow does not require significant financial outlays. It is a cheap method, which, however, is believed to have some negative effects as well. Its major drawbacks include damages to the soil structure and erosion, which can occur, for example, during heavy rainfalls. Also, the soil cultivated as bare fallow releases precipitation water easily, which has a negative effect especially on plants with a shallow root system or those grafted on dwarfing rootstocks. Uncovered soil surface increases the risk of root system freezing during heavy frost and snowless winters. On the other hand, spring and summer are the seasons when the advantages of bare fallow can be fully observed – faster growth caused by the accumulation of water and nitrate in soil and better fruiting of trees. However,

it is believed that this method violates the natural course of processes in the environment [8,9,10].

Using herbicide treated fallow is a popular method of soil care. Herbicides help keep the soil free of weeds, under the canopy or along the whole rows, rendering manual or mechanical weeding unnecessary. Like bare fallow, herbicide treated fallow improves the growth and the yield of trees. Applied to rows of trees, it helps to lower the soil pH quickly – especially in the case of luvisoils, in which conditions, however, it requires regular liming.

The use of herbicide treated fallow is now being phased out due to environmental protection requirements and the attempts at reducing the amount of chemicals used in agriculture [11,12,13,14].

1.3. Characteristics of selected traditional apple tree varieties

The rarest varieties, in need of particular protection, include the following:

Ananas Berżenicki is a variety originally discovered in the Vilnus region as a seed of an unknown variety. Its development is characterised by very intensive growth and the formation of an impressive round crown. Its fruiting period begins fairly late. The initial yield is not particularly heavy. The fruit is large or very large, round-conical in shape, and the ripe flesh is crisp, not very juicy, wine-like sweet, slightly aromatic. It is a typical dessert variety, less fit for preserves. The positive feature of this variety is its resistance to frost, apple scab and mildew [15].

Kosztela, (also known as Wirzebówka zimowa or Kosztylka), is a Polish variety, probably cultivated as early as the 17th century. The tree grows very vigorously and forms a round crown. It yields heavily every

second year, bearing round, medium-sized fruit with green or straw-green, smooth and strong skin, with a slight yellowish blush. The flesh is yellowish, compact, juicy, very sweet and tasty. The fruit ripens very late, even as late as in the third decade of September, and can be stored until the end of January. These trees are frost-resistant and relatively resistant to diseases [15] .

Kantówka Gdańska (Danziger Kantapfel). A Dutch variety. A vigorous grower, the tree forms a broad crown, is frost-resistant and, due to its late blooming, not vulnerable to spring frost. The fruit is large, green-yellow, the skin largely covered with a fuzzy-striped, red blush. The flesh is yellowish, sometimes slightly pinkish, crisp, slightly juicy, aromatic. A perfect dessert variety, also good for preserves. Harvested in mid-September, the fruit can be stored until January [16].

Żeleźniak (Roter Eiserapfel). A German variety. The tree initially grows very vigorously, forming a conical crown; the fruiting begins late and brings moderate yield. The fruit is medium-sized, round, sometimes slightly asymmetrical, the skin all covered with a dark-red blush and when on a tree – also with a bluish waxy layer. The flesh is initially greenish, later white-yellow, compact, firm, crisp, when fully ripe – juicy, sweet-and-sour. The fruit harvested in October is fit for consumption in January, and can be stored as late as until August. Good for preserves (juices and wines) and in spring – for consumption as dessert fruit [16].

Reneta Złota (Queen of the Pippins). An English variety. A moderate grower, the tree initially forms a column-shaped and later – conversely – a conical crown. It crops heavily and alternately. Disease-resistant and medium frost-resistant. The fruit is medium-sized or large, round-conical in shape, the skin is golden yellow with an orange-red,

marble-streaked blush. The flesh is white-yellow, compact, moderately juicy, with spicy aftertaste, tasty. The fruit harvested in the second half of September can be stored until the end of December. It ripens unevenly. Can be used for direct consumption, as well as for preserves [17].

Glogierówka (Pepinka Litewska). A Lithuanian variety. A small grower, the tree forms a modest, rather irregular crown. The fruit is medium-sized, round or slightly elongated. The skin is very thin, delicate, straw-yellow, with a delicate fuzzy red blush. The flesh is delicate, wine-like sweet, aromatic, very tasty. Dessert fruit, good for preserves as well; harvested in September can be stored until December [17].

Charłamowskie (Duchess of Oldenburg). A Russian variety. Moderate grower, the tree forms a broad, round crown and begins to fruit early, showing little resistance to frost. The fruit is medium-sized, cordate-oblate in shape, yellow, with a carmine red stripped blush; the flesh is delicate, crisp, aromatic, sour. The fruit is good for preserves, ripens in August and has a short storage period [18].

Grochówka (Bohnapfel). A German variety, discovered and described between 1750 and 1800. The fruit is small, oval, usually truncated at the calyx and the stock. The skin is thick, smooth and yellowish-green, with a striped red blush. The flesh is greenish, compact, coarse, medium juicy. While stored, it becomes yellowish and better – sweeter – in taste. The harvest is in the second decade of October. The fruit can be stored as long as until June. Late in winter, it can be consumed as dessert fruit. Trees grow moderately. They begin to fruit relatively early and yield heavily every second year. They have small soil requirements. Frost-resistant and not very susceptible to apple scab [18].

2. The causes of the decline of traditional apple tree varieties

Based on the available literature, a characteristic feature – so to speak – of orchards in pre-war Poland was that each could be home to a couple or even a dozen or so of different varieties. Over 150 apple tree varieties were cultivated in Poland at that time, their availability varying locally. As a result of the war, many orchards lost the varieties that were particularly valuable at that time [19,20].

Therefore, when considering the causes of the decline of apple tree varieties previously cultivated in Poland, account must be taken of the changes that took place in Polish post-war fruit farming. Because of the ever increasing market demands at that time, more fertile, better storable and attractively looking varieties became prioritised. Also, intensively-producing orchards began to develop, their main objective being the maximisation of production profits. It was for these reasons that traditional apple tree varieties became less competitive than the annually fruit-bearing varieties that were being introduced. The alternate-bearing feature of the old varieties was their major weakness in comparison to the newly selected varieties, which were also more easily storable and more attractively looking. Other than that, however, it is difficult to explain the decrease in the interest in the traditional varieties, which was particularly noticeable in the 1970s. In spite of the few drawbacks – such as alternate bearing and poor storage qualities – traditional apple tree varieties have many strong points as well. Particularly worthy of mention is their rich taste, praised by the older generations as inimitable and unforgettable [20].

2.1. Legal regulations concerning the protection of traditional fruit tree varieties

The protection of the previously cultivated varieties of apple trees and other fruit trees is crucially important for protecting broadly defined biodiversity. With the idea of sustainable development of agriculture being currently promoted in the country, non-production advantages of many domesticated plants are also being increasingly recognised. Many landscape architects now believe that single specimens of traditional apple trees are an integral element of Polish rural landscape. In recognition of the environmental and landscape value of traditional varieties, a host of government protection and revitalisation measures have been undertaken, both nationally and internationally. New collections of traditional fruit tree varieties are currently being launched in various regions of Poland, which are subsequently advertised for cultivation in pedestrian orchards. These measures implement the regulation of the international Convention on Biological Diversity, which Poland ratified in 1996.In 1992, the European Community reformed the Common Agricultural Policy with a primary view to supporting pro-ecological forms of agriculture in all member states. A good example of applying the provisions of the current policy is Council Regulation (EC) No 1698/2005 of 20 September 2005 adopted by the European Agricultural Fund for Rural Development, which provided the basis for an agri-environmental programme aimed at supporting activities for implementing the major assumptions of sustainable agriculture [21,22].

The said programme contains six packages:

1. Sustainable farming;

2. Organic farming;
3. Extensive permanent grassland;
4. Protection of endangered bird species and natural habitats outside the Natura 2000 areas;
5. Protection of endangered bird species and natural habitats within the Natura 2000 areas; and
6. Preservation of endangered genetic plant resources in agriculture.

The latter of the above-enumerated help packages aims to preserve local varieties of domesticated plants and endangered species of livestock. It is worthy of mention that each of the six packages of the EU Rural Development Programme specifies different variants of funding available to potential beneficiaries. Importantly, however, the applicant's eligibility for a grant is conditioned on meeting a set of specific requirements defined for each of the aid variants. Traditional orchards are covered by the last variant of the agri-environmental programme's sixth package. Funds available in the "Traditional orchards" variant can be obtained if:

- The applicant's orchard includes at least 12 15-year-old or older trees of at least four species or varieties, with crowns at the height of 120 cm or higher. The trunk girth at the height of 1 m cannot be smaller than 47 cm;
- The orchard can be enlarged by up to 40% of the entire tree stocking with at least three species or varieties specified in Annex 4 to the Regulation, or with tree varieties traditionally cultivated in Poland before 1950 (the enlargement should involve the addition of new varieties or species). Trees must be bred on vigorously growing rootstocks and cultivated as standard trees with the trunk height

of at least 1.20 m and the plating space of between 4 x 6 m and 10 x 10 m;

- Basic plant-care procedures are provided, such as: pruning the trees for sanitary purposes and trimming overly dense crowns, removing outgrowths and self-seedings, bleaching the trunks of old trees and protecting young trees against rodents, maintaining overall order in the orchard [23].

The diagram below presents the number of Variant 6.4 (Traditional Orchards) applications filed, with a breakdown by province.

Habitat conditions in Poland differ considerably. Soil-climatic conditions vary depending on the province. For this reason, the provincial level is characterised by a considerable diversification in the number of applications filed for EU funds dedicated to the protection of indigenous varieties. Figure 1 shows that the highest numbers of applications were filed in Małopolska and Świętkorzyskie Provinces, while those with the least interest in this type of funds were Opole, Lubuskie, Pomerania and West Pomerania Provinces.

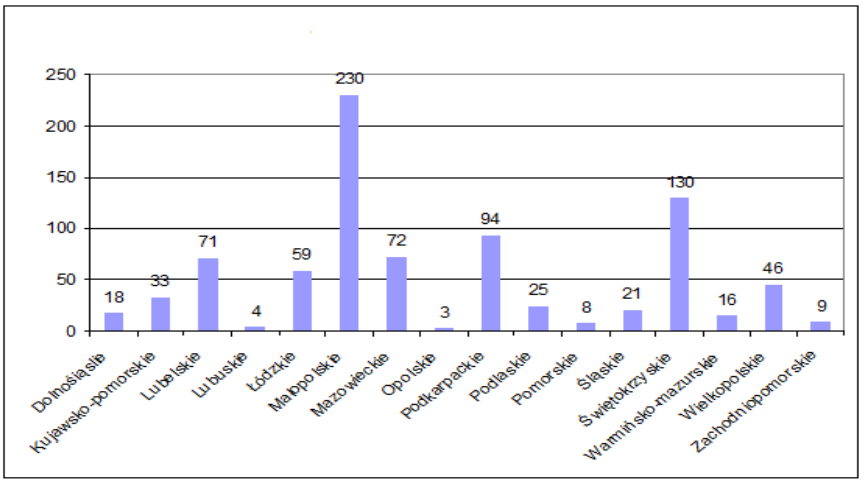

Figure 1. The number of Variant 6.4 (Traditional Orchards) applications filed, broken down by province

Dolnośląskie – Lower Silesia P.; *Kujawsko-pomorskie* – Kujawy-Pomerania P.; *Lubelskie* – Lublin P.; *Lubuskie* – Lubuskie P.; *Łódzkie* – Łódź P.; *Małopolskie* – Małopolska P.; *Mazowieckie* – Mazovia P.; *Opolskie* – Opole P.; *Podkarpackie* – Podkarpacie P.; *Podlaskie* – Podlasie P.; *Pomorskie* – Pomerania P.; *Śląskie* – Silesia P.; *Świętokrzyskie* – Świętokrzyskie P.; *Warmińsko-mazurskie* – Warmia-Masuria P.; *Wielkopolskie* – Wielkopolska P.; *Zachodniopomorskie* – West Pomerania P.

Source: Agri-environmental advisers training, 24–25 November, 2009, held at the Agricultural Advisory Centre in Brwinów, Radom Branch: "Implementation of agri-environmental programmes 2004–2013". Tomasz Stachowicz (based on data by the Agency for Restructuring and Modernisation of Agriculture)

3. Conclusions

1. Reducing eligibility requirements for farmers applying for funds dedicated to the preservation of traditional orchards may significantly increase their interest in cultivating traditional fruit tree varieties.
2. Offices and institutions lack detailed information about the preserved specimens of traditional fruit tree species in particular provinces.
3. Important advantages of traditional apple tree varieties include outstanding palatability and disease-resistance. Therefore, increasing the funds for preserving indigenous varieties and their better promotion

on local markets may make them more interesting for both producers and consumers alike.

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Biochemical monitoring of water contaminated with petroleum substances and heavy metals

Keywords: *petroleum substances, heavy metals, monitoring*

Summary: The objective of this paper is to assess water quality of 3 rivers (Lubka, Narew and Horodnianka) and 3 wells (in Dydule, Czarny Blok and Czuprynowo) in Podlaskie voivodeship (Poland). To the tests has been used water taken directly from river or well to the glass bottle. There have been examined 7 parameters: pH, electrical conductivity, redox potential, Biochemical Oxygen Demand, Chemical Oxygen Demand, Mineral Oil Index, concentration of heavy metals (lead, nickel, iron, manganese, chromium, cadmium, zinc), each one in 4 series. Exams, that have been carried out in this paper, allowed to rate water quality as not satisfying, i.e. one of the wells (in Dydule), that is placed in agricultural area, is highly polluted with mineral oil, while well in Czarny Blok (located near train tracks) has lower concentration of this. It is caused probably by different kind of soil in this two places. The highest level of MOI is in Czuprynowo well near KREX company (that deals with liquid fuels and coal). The contamination of water by heavy metals is also quite high, in most cases, disqualifying water from the purest classes. The worst situation is with lead and cadmium. This two very toxic metals exceed the acceptable level few times. Tests also allowed to find out, that ground water in many cases has higher contamination than surface water. It also showed, that water protecting activities are not enough and should be continuously advanced.

1. Introduction

Drinking water, it means water, which can be drunk by people and not cause any diseases or death, is a necessary element for living organisms. It should be pure and devoid of any admixtures, except mineral elements, that get into the water in a natural way, by rocks dissolution. Water is the best solvent occurring in nature. Most of known compounds (in amount of about 2500) quickly and easily dissolve in water. Those compounds can pollute environment and their detection by human senses is almost impossible. That is the reason that the regular and reliable biochemical monitoring is so important. Water quality assessment involves, inter alia, oxygen indices: Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), redox potential, acidification (pH), salinity (electrical conductivity), heavy metals content (lead, cadmium, zinc, iron, manganese, chromium, copper) and mineral oil content (Mineral Oil Index – MOI).

Surface water includes just a few percent of all amount of water on the Earth [5]. This group is most exposed to harmful effects of human activities. It is caused mainly by excessive input of inorganic matter (solid, liquid or gaseous), organic matter, radioactive matter and even heat. Most often into the water get pesticides, phenols, surfactants, polychlorinated biphenyl, heavy metals and petroleum substances.

Underground water includes about 97% of all amount of water on the Earth. It is covered by low permeable rocks, moreover the exchange of underground water is very slow, it lasts even hundreds or thousands years. That is why it is considered as safer than surface water. Many underground water resources were formed before the Industrial Revolution,

therefore they should not be contaminated with contemporary impurities. Slow water exchange could be also a huge disadvantage of those type of water: the contamination is present there for a very long time until the reservoir undergo self-cleaning.

Growing problem of water quality is pollution with petroleum substances, because their penetrability through the soil and migration is quite high. Sources of this kind of substances are: petrol stations, refineries, industrial pipelines, storage facilities and handling, industrial areas and postindustrial fields, airports and military bases as well as track and railway sidings, car or train accident places, car washes, asphalt pavements, landfills. In view of highly toxic character of this compounds every spill could be a reason of disaster for plants, animals and people.

Petroleum, when released into the water, covers its surface with very thin layer, which makes the oxygen supply impossible. This in turn limits growth of water organisms. Some part of hydrocarbons vapors. Acids and inorganic salts contained in petroleum are dissolved and the rest emulsifies. Water contamination is more often visible without any measurements, it forms oil stains. One milliliter of petroleum is able to cover 12 m^2 of water surface [4]. When the water is insignificantly polluted with hydrocarbons, their summary concentration equals 0,01-1 g/m^3. When the pollution with hydrocarbons is considerable, their concentration equals even a dozen or so grams per cubic meter [3]. In underground water that indicator is rarely higher than 0,01 g/m^3, but the permeation rate of petroleum through the soil is 6-10 times higher than water. That proves, that there is no safe water.

Hydrocarbons in water are gradually decomposed. Mineralization of one gallon of petroleum require 320 000 gallons of water saturated with

oxygen [3]. That is why very often water polluted with petroleum substances does not contain that gas.

Hydrocarbons are able to penetrate the human skin, digestive and respiratory systems and accumulate there. Effects of their presence in organism could be serious, they can cause cancers, fetal damage, breast-feeding mothers can have contaminated milk. Their hydrophobic character facilitate their dissolution in fat and next getting into the nervous system. Then it induce paralyzing and narcotic effects. Most hydrocarbons is metabolized mainly in liver and kidneys, but products of this process are toxic. The rest is accumulated in adipose tissue. Chronic exposure to water contaminated with oil substances leads to hormonal disturbances and distorted hematopoiesis (reduction in the number of erythrocytes, hemoglobin content in the blood) [7].

Heavy metals are another problem of water pollution. Two features make them dangerous and harmful: they are not biodegradable and they are easy absorbed and cumulated in protoplasm of water organisms [11]. Their toxicity depends on the concentration in the environment, biochemical reactions and absorbed dose [15]. Each of heavy metal has different properties and influence on organisms.

Main sources of heavy metals are: dyestuffs industry, batteries, artificial fertilizers, automotive industry, electrochemical industry, refineries, metallurgical industry, petrochemistry, tanning industry and many more [10, 12, 15]. Ways how heavy metals can get into living organisms are shown in the picture 1.

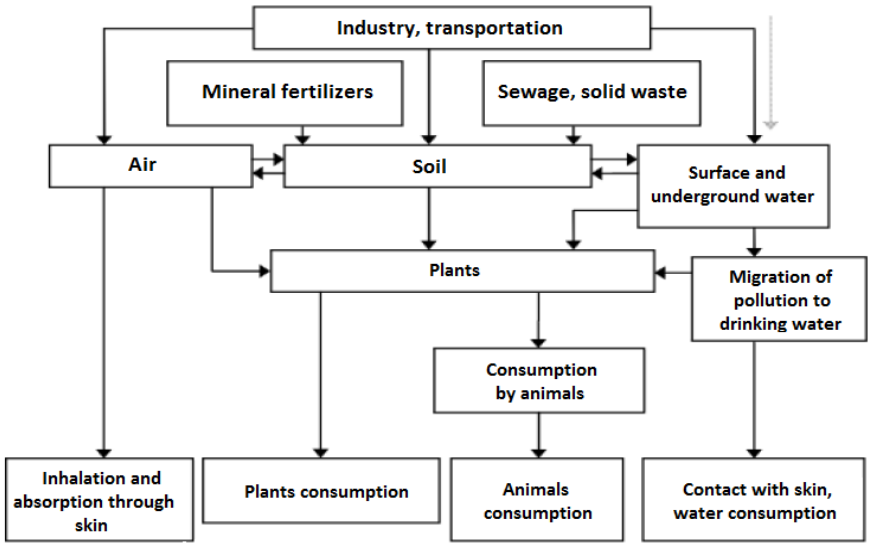

Figure 1. Heavy metals circulation in the environment

Source: Own elaboration based on [6]

The aim of that paper is to assess the quality of water polluted with petroleum substances and heavy metals from transport and communications.

2. Methods

Samples of water have been collected in six locations around the Białostocki and Bielski districts in Poland, where author was expecting exceeded level of petroleum substances and heavy metals. Three of them were rivers and other three – wells.

Figure 2. Location of places, where samples have been collected: A - Lubka River, B - Narew River, C - Horodnianka River, D - well in Dydule, E - well in Czarny Blok, F - well in Czuprynowo

Source: Own elaboration

First point is on Lubka River in Bielsk Podlaski (geographical coordinates: 52.765288, 23.190707) near the railway track of line Białystok - Czeremcha and under the road. The second point is on Narew River near the bridge between Ryboły and Chraboły on national road 19 (geographical coordinates: 52.902185, 23.232349). Third one is on Horodnianka River in Horodniany (geographical coordinates: 53.086443, 23.109044) on regional road 678, under the bridge.

Next three points are wells located in places, where is different degree of urbanization. First is well in Dydule from the 1950s (geographical coordinates: 52.656611, 23.200595). Total depth of the well is about 8 m, to the level of water about 5 m. It is near the road from Gredele to Krasna Wieś, about 3 km on North from the well is railway track from Białystok to Czeremcha. Second one, also from 1950s, is near train station

in Czarny Blok (geographical coordinates: 53.24444, 23.2090977) on railway track from Białystok to Sokółka. It was dug up 7 meters from track. Last well from 1970s is in Czuprynowo (geogrphical coordinates: 53.4691745, 23.6319272), near railway track from Sokółka to Kuźnica. Its total depth is 9 m, to the level of water 5 m. Near is handling and production terminal "KREX" Sp. z o. o. (dealing with solid and liquid fuels).

From each place, mentioned above, the sample has been taken four times, every two weeks. Water from rivers have been collected directly to glass bottles of volume 1 liter, by dipping it. Water from wells have been collected to metal bucket and then poured to the glass bottles of volume 1 liter. It has been stored in dark and cool places.

Samples were tested for pH, electrical conductivity, redox potential, Biochemical Oxygen Demand, Chemical Oxygen Demand, Mineral Oil Index, concentration of heavy metals (lead, nickel, iron, manganese, chromium, cadmium, zinc) according to current research methods.

Table 1. Specification of methods and devices used in tests

Parameter	Device/method
pH, redox potential	YSI EcoSense pH100
electrical conductivity	ELMETRON CPC-401
BOD	BZT OxiTop Control (manometric method)
COD	Dichromate method
Petroleum substances	GC with detector VARIAN 4000 in column VF-5MB (30m x 0,25mm x 0,2μm); stationary phase was polydimethylsiloxane with a 5% of phenolic groups
Heavy metals	VARIAN AA-100 (atomic absorption spectroscopy)

Source: Own elaboration

3. Results

All the tests were led in the laboratories of Białystok University of Technology on:

I. 22.10.2014
II. 05.11.2014
III. 19.11.2014
IV. 03.12.2014

Numeration mentioned above is used to presentation of results. Samples were collected on that days, because it is the period of frequent rains and petroleum substances as well as heavy metals were rinsed well from the pollution source to the water. Numeration of samples is as follows:

1) Lubka River
2) Narew River
3) Horodnianka River
4) Well in Dydule
5) Well in Czarny Blok
6) Well in Czuprynowo.

3.1. pH

Table 2. Results of pH measurements

pH[-]					
Sample number	**Sequence of measurements**				**Average**
	I	**II**	**III**	**IV**	
1	7,64	7,37	7,58	7,68	7,57
2	7,71	7,66	7,73	7,85	7,74
3	7,61	7,55	7,56	7,51	7,56
4	7,53	7,39	7,48	7,55	7,49

5	7,63	7,59	7,60	7,70	7,63
6	7,93	8,04	7,96	7,90	7,96

Source: Own elaboration

According to Foregs Atlas portal, pH of natural water should be between 5 and 9 [13] and the average in Europe is 7,5 [14]. All the samples meet the first criterion and at the same time they are close to the average. One of them, from Lubka River, taken on 05.11.2014 is too low in comparison to another ones. Probably it is the reason of the fact it was raining in Bielsk Podlaski at the beginning of November. Rainwater has pH about 5,6, so it could acidify the surface water. Moreover, pH does not suggest high concentration of carbon dioxide in the samples, otherwise pH should be lower than 6. There is a big probability, that high pH of the water from Czuprynowo causes limescale buildup.

3.2. Electrical conductivity

Table 3. Results of electrical conductivity measurements

Electrical conductivity [µS/cm]					
Sample number	**Sequence of measurements**				**Average**
	I	**II**	**III**	**IV**	
1	789	865	801	872	832
2	354	373	398	424	387
3	307	347	388	375	354
4	672	674	726	690	691
5	308	321	345	302	319
6	253	170	179	194	199

Source: Own elaboration

Electrical conductivity for surface water should have a value between 2 and 100 µS/cm and for underground water it should be 50 - 50 000 µS/cm [8, 9]. As can be noticed, surface water (samples 1-3) does not

fulfill that scope. Their values far exceed acceptable level, what proves a high concentration of ions of inorganic salts (organic salts dissociate less than inorganic). High electrical conductivity can be a reason of surface runoff containing mineral fertilizer, because all rivers are flowing through agricultural areas.

In case of wells all the values meet the range of conductivity for underground water. The highest is in well in Dydule (sample 4), because it is a strictly agricultural area and much fertilizers get into the water. Samples 5 and 6 are not from the area, where inorganic ions are used in any way, that is why their concentration is lower.

3.3. Redox potential

Table 4. Results of redox potential measurements

Redox potential [mV]					
Sample number	**Sequence of measurements**				**Sample number**
	I	**II**	**III**	**IV**	
1	-57	-58	-45	-61	-55
2	-60	-64	-60	-39	-56
3	-48	-57	-59	-61	-56
4	-71	-53	-69	-64	-64
5	-67	-65	-82	-65	-70
6	-60	-69	-63	-62	-64

Source: Own elaboration

Surface water should have redox potential from +300 to +500 mV and underground water from -200 to +100 mV [2, 8]. It means, each sample of surface water (samples 1-3) is below the theoretical range. Underground water in that case fully meets the norms.

3.4. Biochemical Oxygen Demand

Table 5. Results of BOD measurements

BOD [mg O_2/dm^3]					
Sample number	**Sequence of measurements**				**Average**
	I	**II**	**III**	**IV**	
1	4	6	4	3	4,25
2	0	3	2	2	1,75
3	4	3	3	2	3,00
4	3	3	< range	1	1,75
5	< range	1	1	2	1,00
6	1	1	1	1	1,00

Source: Own elaboration

From the table above follows, therefore, that BOD in underground water (samples 4-6) is lower than in surface water (samples 1-3). That situation is an advantage, because it means, that underground water do not have any contact with organic pollution and pollution cannot penetrate the soil. Rivers have direct contact with this kind of contamination because of the presence of herbicides, detergents, food waste, mineral oils and petroleum substances in the environment.

3.5. Chemical Oxygen Demand

Table 6. Results of COD measurements

COD [mg O_2/dm^3]					
Sample number	**Sequence of measurements**				**Average**
	I	**II**	**III**	**IV**	
1	22,1	27,6	40,3	47,9	34,48
2	25,6	25,2	41,5	27,7	30,00
3	43,9	20,8	36	21,4	30,53
4	6,7	4,7	11,7	5,4	7,13
5	111	88	83	113	98,75
6	30	35,8	19,5	14,5	24,95

Source: Own elaboration

BOD values are always lower than COD values, because they are just their parts. Moreover, ratio BOD/COD is also important. When it is close to 1, pollution in the water is perfectly biodegradable. The tables show that no sample is like that. Just water from well in Dydule (sample 4) is closest to be perfectly biodegradable (BOD/COD=0,25). COD value in sample 1 significantly grows in time, what suggests, that organic substances got into the water. In sample 2 during third test COD was very high in comparison to another tests. That could be caused by incidental contact of water with organic pollution.

Chemical substances being oxidized when treated with potassium dichromate (VI) are carbohydrates, aliphatic and aromatic compounds with substituents. Others, like pyridine, benzene and its homologues, heterocyclic compounds containing nitrogen, urea, paraffins, naphthenes and other compounds slightly soluble in water practically does not oxidize in this method. Not all organic substances present in the sample were measured.

3.6. Petroleum substances

Table 7. Results of MOI measurements

MOI [mg/dm^3]					
Sample number	**Sequence of measurements**				**Average**
	I	**II**	**III**	**IV**	
1	1,2900	0,4315	0,3083	0,3371	0,5917
2	0,9731	0,9230	0,3086	0,3944	0,6497
3	0,8398	0,4022	0,3352	1,1460	0,680
4	0,6114	0,4609	0,3269	0,3371	0,4340
5	0,3830	0,4091	0,3089	0,3236	0,3561
6	1,8605	0,5742	0,3176	0,3246	0,7692

Source: Own elaboration

Water quality cannot be classified as satisfying. The level of petroleum substances in each sample exceeds admissible concentration. Furthermore, there are large deviations in single results, probably caused by measurement error. Petroleum substances average content is higher in surface water than in underground water. There was prepared a chart showing the relation COD to MOI.

The tests have not show any relation between COD and MOI values. Theoretically, when concentration of petroleum substances grows, COD should grow, too. The reason could be that sometimes sample of water has low COD and high MOI (and vice versa). It depends on conditions and time. Rains reduce the pH of water and increase the mobility of oil, but it get into the water after some time, when rinsed from the ground, road or railroad track. When water pH is high (like in that situation), petroleum substances are in precipitated form and their measurements are not reliable.

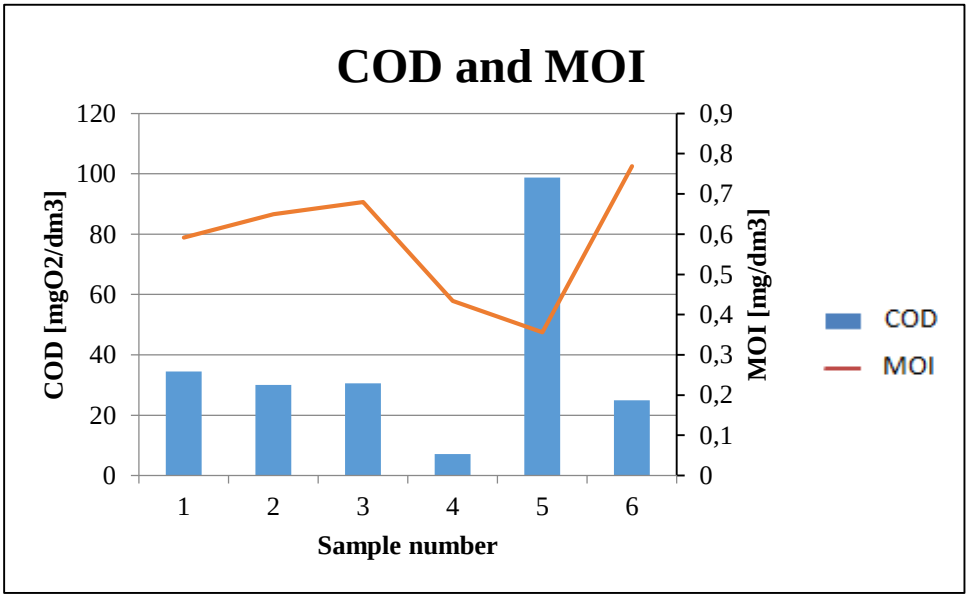

Figure 3. Relation between COD and MOI

Source: Own elaboration

Tab. 8. Results of heavy metals measurements

Sample number	Sequence of measurements			Average
	II	III	IV	
Nickel concentration [mg/dm^3]				
1	0,025	0,041	0,056	0,0407
2	0,011	0,045	0,027	0,0277
3	0,036	0,038	0,054	0,0427
4	0,025	0,042	0,069	0,0453
5	0,046	0,050	0,050	0,0487
6	0,046	0,043	0,050	0,0463
Lead concentration [mg/dm^3]				
1	0,70	1,12	0,90	0,9067
2	0,50	1,27	0,67	0,8133
3	0,92	1,14	1,09	1,0500
4	0,95	1,17	0,92	1,0133
5	0,76	0,94	0,87	0,8567
6	1,14	0,89	1,10	1,0433
Sample number	**Sequence of measurements**			**Average**
	II	**III**	**IV**	
Iron concentration [mg/dm^3]				
1	0,137	0,108	0,139	0,1280
2	0,190	0,049	0,400	0,2130
3	2,059	0,070	0,162	0,7637
4	0,065	0,014	0,093	0,0573
5	1,290	0,025	0,096	0,4703
6	0,069	0,036	0,080	0,0617
Manganese concentration [mg/dm^3]				
1	0,054	0,001	0,033	0,0293
2	0,004	0,011	0,153	0,0560
3	0,344	0,017	0,078	0,1463
4	0,008	0,012	0,022	0,0140
5	0,003	0,008	0,020	0,0103
6	0,005	0,016	0,017	0,0127
Chromium concentration [mg/dm^3]				
1	0,014	0,035	0,025	0,0247
2	0,011	0,047	0,015	0,0243
3	0,051	0,040	0,022	0,0377
4	0,034	0,056	0,004	0,0313
5	0,010	0,046	0,013	0,0230
6	0,068	0,014	0,033	0,0383

Cadmium concentration [mg/dm^3]				
1	0,015	0,009	0,004	0,0093
2	0,011	0,009	0,006	0,0087
3	0,004	0,012	0,001	0,0057
4	0,006	0,019	0,003	0,0093
5	0,010	0,019	0,007	0,0120
6	0,007	0,016	0,004	0,0090
Sample number	**Sequence of measurements**			**Average**
	II	**III**	**IV**	
Zinc concentration [mg/dm^3]				
1	0,1322	0,0427	0,0928	0,0892
2	0,1469	0,0130	0,2303	0,1301
3	0,1122	0,0253	0,0728	0,0701
4	0,0909	0,0349	0,0797	0,0685
5	0,3035	0,1916	0,2453	0,2468
6	0,0860	0,0247	0,0762	0,0623

Source: Own elaboration

There has been drawn up a chart showing the relation between concentration of cadmium, lead and MOI.

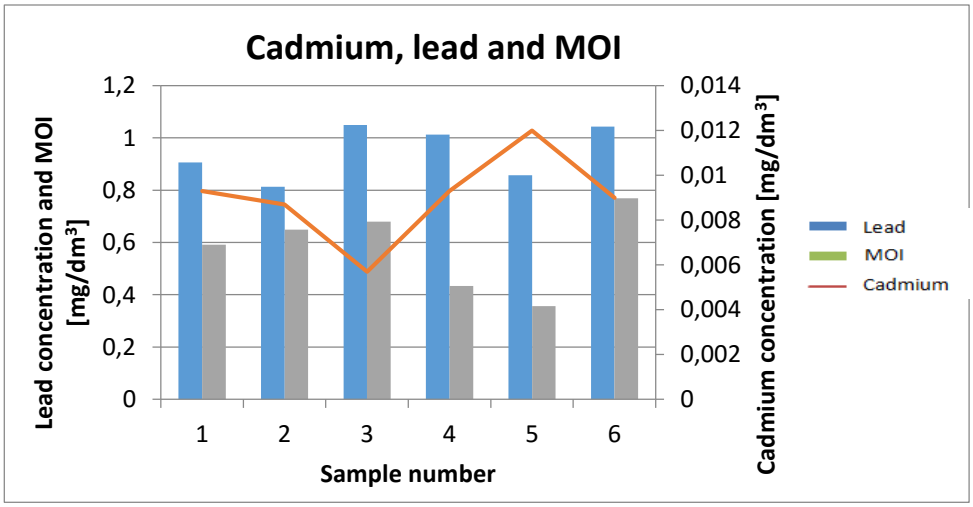

Figure 4. Relation between lead concentration, cadmium concentration and MOI

Source: Own elaboration

Diagram shows, that the concentration of cadmium is inversely proportional to MOI. There is no any relation between lead and MOI

or lead and cadmium observed. Lead is present in samples, when cadmium is present there.

4. Conclusions

Research, that have been carried out, allowed to assess the water quality as bad. It should contain just substances, that get into there in a natural way. The problem is, that the situation like this is impossible to achieve nowadays. That is why the monitoring and constant drawing conclusions are so important. Samples of water from all sources contain too much petroleum substances. The level of the concentration is similar in surface water, but underground water differs sample from sample a lot. Also the concentration of heavy metals (especially lead, nickel and cadmium) is too high. Worth noting is the fact, that the tests were done in the autumn, and during the winter the concentration could be even higher [1]. According to another research, the mobility of heavy metals is inversely proportional to pH. In the autumn, when it rains often, water is acidified, thus heavy metals are increasing their mobility and it is possible to test them.

All the arguments prove, that locations, time and methods were optimum. Measures taken to protect the environment are not efficient. It is definitely not safe to use water from the areas described in that paper as a drinking water. The conclusions after finishing the tests are following:

1. In underground water the concentration of lead, nickel, cadmium and zinc is higher than in surface water.
2. The petroleum substances and heavy metals concentrations were lower in underground water, what means they are safer for living organisms.
3. Petroleum substances are not perfectly biodegradable.

4. Concentration of pollution is varying in surface water very quickly, in underground water it is slower process.
5. In terms of physicochemical parameters the quality of water is bad and the activities protecting the environment are not efficient.

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Thermal methods of municipal waste treatment

Key words: *thermal methods, municipal waste, environmental, utilization, plasma, pyrolysis*

Summary: Municipal waste is defined as wastes generated by households. As well as the waste not containing for hazardous waste from other of waste producers which by their nature or composition are similar to waste from households. In accordance with requirements of the Environmental Law waste must be treated prior to storage. One way is the thermal disposal - commonly called combustion. Article presents a literature review of available thermal methods of municipal waste. Properly conducted processes are not harmful to the environment and people's lives. Generated combustion gases and ash do not emit odours and are not a threat. The application of thermal methods of municipal waste treatment allows for very high volume reduction of waste and the lack of time constraints in the disposing and recycling of energy. The type of technology is closely related to the investment and running costs.

1. Introduction

At present the dominant way of dealing with waste management in Poland is its storage. In view of the recommendations of the European Union (Directive 2008/98/Ec) and the constantly increasing storage costs (both in the categories economic and social) are dealt with various forms of action. These measures are intended to reduce the volume of waste and dispose their maximum economic use. The result of this process is to protect the environment from the negative landfill impact [1,19].

The main methods commonly used to reduce the amount of landfilled waste can be divided into the following sections:

- materials recovery possible for economic utilization;
- composting of biomass;
- anaerobic digestion of biomass and biogas recovery;
- thermal processes (combustion, mineralization).

Thermal utilization is mainly used for the disposal of waste, which use is not possible and due to the nature, which characteristic or quantity are particularly dangerous to health, air or water, threaten the explosion, as well as contain, or may promote the spread of infectious diseases. These are generally for such types of waste that contain organic compounds in large quantities or with a high potential danger.

The effect of thermal waste treatment can be:

- significant reduction of danger from pollutants contained therein,
- reducing the number and volume,
- adjusting remaining after the co-incineration residues into a usable or storage,
- energy recovery.

The lack of effective measures to curb the stream of waste (eg. through the implementation of low and non-waste technology) resulted in a situation which the landfill already exhausted the possibilities of this method. Attempts to solve this problem (among others through the implementation methods of waste co-incineration) meet currently undecided social resistance, expressed in many protests against waste co-incineration plant in the area. Protests that accompanied the most discussion in which rational and factual arguments are not often articulated [1]. It is not surprising such a social feeling towards the plant in a country

where about 15 years a lot of environmental organizations proves a great threat to the environment and the health of the people from objects of this type [2]. It is known that the lack of industrial experience in the operation of such facilities in the country is the main reason for having to use information available only in foreign reports. At present operating in Western Europe waste co-incineration plants are subject of a lot factors in determining their role and place in the waste management system.

The basic ones include [3]:

- the location of combustion installations as one of the links comprehensively implemented waste management system,
- the use of modern, environmentally safe waste co-incineration plant, or Best Available Technologies (BAT) (Council Directive 96/61/EC),
- optimal use of the energy contained in waste residue, ensuring the highest technical and economic efficiency installations and combustion,
- location in area having appropriate technical infrastructure, and ensuring for the possibility of obtaining the highest possible social approval,
- conducting the project and investment procedures with full and comprehensive informing public opinion, together with information on the amount of investment and the costs that will be faced with the residents from the operation of the entire waste management system.

In EU countries, the management of waste at landfills is a last resort. Expedient becomes the search for rational methods waste management for both municipal and industrial, which can be used. One such method is the thermal treatment of waste in an approved or co-incineration with conventional fuels [4,5,6,7,20].

2. Environmental safety of waste co-incineration plants

Waste incinerators are viewed as a potential source of emissions of many toxic substances into the air. In the heterogeneous combustion of fuel, which may arise waste a lot of substances known to be harmful and sometimes even poisonous, they include:

- dust coming from a non-combustible fraction of waste, which is also a great many media of heavy metals such as chromium, nickel, lead, cadmium, mercury, and many others,
- dioxide and carbon monoxide as the natural products of the hydrocarbons combustion process forming organic matter are burnt,
- sulfur dioxide as a consequence of present in the waste material containing sulfur,
- nitric oxide (oxide, carbon dioxide and nitrous oxide) as a consequence of the presence of waste of substances containing chlorine and fluorine,
- organic micropollutants coming from incomplete thermal decomposition of organic matter - the total identified in the co-incineration of waste co-incineration over 300 chemical compounds including simple carbohydrates, aliphatic and aromatic hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids, simple, easy chlorinated hydrocarbons (aliphatic and aromatic) or the like,
- polychlorinated dibenzo - p - dioxins and polychlorinated dibenzofurans simplify called dioxins and furans (PCDD / PCDF).

As a potential source the greatest threat posed by waste co-incineration plants are considered of dioxins and their emission is key argument of opponents incinerator. The second place is usually exchanged

heavy metals, including inter alia, mercury, cadmium, and arsenic also emitted from waste incinerators. In addition, incinerator opponents also argue argument incinerated secondary solid waste (slag, fly ash, flue gas cleaning products), containing many compounds that may have a negative impact on the environment. Sometimes the argument is also likely to arise in the plant toxic sludge [8].

Today, with the current state of knowledge, there may be concluded that the latest generation of waste incinerators (the nineties) provide almost complete elimination of pollution from the exhaust to a safe level for the environment and people. Several years of experience operating the most modern waste co-incineration plants have shown that it is possible to significantly improve the eco-friendliness of the co-incineration process are met certain requirements.

A necessary condition of ecological safety during the operation of the incinerator are secondary-type projects, consisting in use of highly efficient cleaning and neutralizing nodes exhaust gases.

Diverse and variable during the combustion of waste being handled makes it very difficult to precisely determine the contribution of each component of pollutants in the exhaust. Therefore the applied method of purification and neutralization system has to take into account in their assumptions interrelated ways of working that, even when significant variations in the concentration of pollutants in the exhaust gases leaving the boiler last string, it can be effectively reduced to the limits required by the applicable standards. In addition, ecological safe combustion installation should be equipped with devices for processing and disposal of solid combustion products, it is slag, dust and ashes, as well as post-

reaction residues or waste water resulting from flue gas cleaning technology used [3].

New incinerators comply with the strictest standards, the concentration of pollutants in the exhaust are usually below 10% of the limit values specified in the regulations. Exhaust gas cleaning systems in the latest municipal waste co-incineration plants are very complex and multi-stage. Their task is to remove most of the pollutants in the exhaust. Removal efficiency is usually at a level of from 95 to over 99% [3].

3. Thermal methods of municipal waste treatment

Thermal waste treatment (in accordance with the Waste Act - Dz. U. 2013 nr 0 poz. 21) is the process of oxidation of waste (to be added under thermal conditions), including combustion, gasification or decomposition of waste, including pyrolytic decomposition carried out in dedicated installations or devices (eg co-incineration of waste) on the terms specified in the detailed rules [9,21].

Thermal methods of municipal waste treatment:

1. Pyrolysis
2. Combustion rotary kiln
3. Waste co-incineration furnace with extensible and grid fireplace fixed or mobile
4. Co-incineration in cement kilns
5. Co-incineration in power equipment
6. Combustion in fluidized furnaces
7. Thermal destruction in microwave devices
8. Plasma thermal destruction

3.1. Pyrolysis

Pyrolysis is process of thermal transformation of carbon-rich organic material, which takes place at elevated temperature in an environment completely devoid of oxygen or with its small presence. This process is endothermic (requires a supply of heat to the outside) and extends at temperatures up to 1000°C. The composition and amount the pyrolysis products depends on the type of waste, their physicochemical properties and the process temperature. During the pyrolysis process the waste mass is converted to:

- pyrolysis gas containing mainly hydrogen, methane, ethane, and their homologues, carbon monoxide and carbon dioxide and other compounds such as hydrogen sulfide, ammonia, hydrogen chloride and hydrogen fluoride;
- pyrolysis coke - solid phase containing carbon and metals and other substances;
- a liquid phase containing a mixture of oils, tars and water, and dissolved therein simple aldehydes, alcohols and organic acids.

Among the products of pyrolysis has the largest share of the liquid phase (approx. 60% regardless of the pyrolysis temperature), while with increasing temperature decreases amount solid phase for the benefit gaseous phase.

Preparation of waste:

Mixed municipal waste before giving them to the reaction chamber must be subjected to a pre-prepared or crushing and milling to their composition has a maximum unified. The waste should have a very low moisture, because its high content results in the formation of a large amount

of post-processing water. Post-process water needs to be cleaned before its reuse or discharge into the environment.

Pyrolysis gas

The resulting pyrolysis gas is a mixture of gases such as hydrogen, methane, carbon monoxide, also contains organic components. A typical pyrolysis gas has a calorific value of 10-20 MJ/m^3. In the case of co-incineration of municipal waste calorific value of the pyrolysis gas obtained is from 5 to 15 MJ /m^3 and from 15 to 30 MJ /m^3 to the conversion of high energy of refuse-derived fuel fraction. Synthetic gas can be burned in a boiler without being subjected to cooling and purification. Then the gas has to be passed through the exhaust gas cleaning system to be complied emission standards. Due to a large contaminating synthetic gas oils and tars, it is necessary subjecting it to condensation to precipitate the pollution and purification so that it can be used for combustion outside the installation. Thus prepared gas could be used in a gas turbine, but purification is costly and does not guarantee fully obtain expected purity gas. The unpurified pyrolysis gas is not adapted for combustion in engines due to the high content of tar in gaseous, which would be condensed prior to entering the motor [11].

3.2. Combustion in rotary kilns

Combustion in rotary kilns is the most common method used for the co-incineration of dangerous waste due to the high temperature achieved, the long residence time of the exhaust and universal system of the combustion chamber. In dangerous waste co-incineration plants, equipped with a rotary kiln and secondary combustion chamber may be fired following industrial waste:

- liquid substances, such as. solvents,
- substances giving up pumped, like settlement,
- waste in paste form,
- solid substances and liquid at a temperature below the ignition temperature.

The rotary kiln is divided into four zones of thermal load:

- zone inlet temperature of 400°C,
- zone melting and vaporization temperatures up to 900°C,
- combustion zone temperature to 1200°C,
- firing zone and secondary combustion temperatures up to max. 1500°C (in special cases up to 1500°C).

Complete burning the waste is obtained at the time of combustion from 50 to 70 minutes. Combustion temperature control is achieved by selection of feedstock and by controlling the flow of air. The combustion chamber is required temperature 1000 -1200°C, with a residence time of flue gas from 2 to 3 seconds. Because co-incineration of dangerous waste should also comply with the BImSchV (Federal Regulation on Protection against emission) is required costly purification of exhaust gases. This node is basically solved, as in municipal waste incinerators.

The liquid waste is injected over water cooled burner, on the front side of the oven, a direct result of the pressure in the annular supply line. Another possibility is the introduction of solutions directly into the combustion chamber.

Waste the consistency of dough or paste are supplied into the rotary kiln by means of a twin-chamber piston pump directly from the storage container through a nozzle water-cooled. Some of such waste are delivered in closed containers (barrels). Then they are transported by means

of a winch from storage to the height of the hopper. Then moves them to the same hopper protected by a pre-chamber sluice. To the hopper is also fed with solid waste tank by a crane. Through the hopper waste are loading directly into the furnace [10].

Waste in the form of gas injected in directly into the combustion chamber [10].

3.2.1. Waste co-incineration furnace with extensible and grid fireplace fixed or mobile

Installations with grate furnaces are the most common group of technology used for municipal waste co-incineration. It is currently the most popular and most widely used solution in the EU countries. Grate technology, the most mature technology, with known parameters of economic construction and operation, allows you to convert all types of municipal solid waste in this high-energy fraction of waste, as well as on the principle of co-incineration - dehydrated sewage sludge and uninfected medical waste. Full integration grate, furnace and boiler is the most important element for the installation to work efficiently and above all, safe for the environment.

The most important element furnace grate is the grate. Any type of grid must meet specific requirements for the method of supplying primary air under the grate, a possible additional cooling (water when the calorific value of the waste is high and the cooling air is insufficient), the speed of movement and mixing of the waste. The residence time of the waste on the grid is usually no more than 60 minutes. Grates can be fixed or mobile, horizontal or sloping, cylindrical, reciprocating. The most common and most frequently used is a reciprocating grate due

to its reliability and excellent technical parameters. The quality of the waste burn is very high. The grate is made up of grate bars arranged staggered in the sections spanning the width of the furnace. The appropriate movements of grid provide the required level of mixed waste and cleaning slits for supply of air to the combustion process (primary air, which also meets the roles of coolant grate). The displacement of grid in the opposite direction to the movement of waste allows the formation of a uniform layer and the elevation of the top of the grid parts by weight of an incandescent drying and igniting the newly supplied waste. There are many variations of this type of grates with additional moving sections and other combinations [11].

In the case of reciprocating grate, the shape of grid and supply of the primary air should ensure the amount minimization of the fine fraction sieved under the grate. This should provide the quality of ash bottom and slag not only required by law, but also the regular distribution of the primary air over the entire surface of the grate [11].

The combustion process takes place above the grate in the furnace chamber. As a whole, the chamber consists of a grid located at the lower part, cooled and not cooled side walls of the oven top roof. The gases generated by combustion of municipal waste have high volatility, thus the combustion process itself takes place over a grate and only a small portion on the grill. The construction of the boiler must provide legally required dwell time of the exhaust gas in the hot part of stove, at a temperature chosen so that for at least 2 seconds does not fall below 8500°C [11].

Recovery of energy takes place in the waste heat boiler, where heat from the exhaust gases is used for steam production. The percentage of energy recovery from full condensation of waste thermal treatment, thus

production of electricity varies from 19 to 25%. In the cogeneration of heat and electricity efficiency of energy recovery ranges from 74 to 85%.

Advantages:

- thermal treatment of municipal waste with energy recovery is a mature, proven and widely used technology,
- energy recovery at a high level to 85%, with work of installation mode associated with the production of electricity and heat - Combined Heat and Power,
- the possibility of thermal treatment of mixed municipal waste (without the need for costly waste preparation) as well as energy waste of fractions - Refused Derived Fuel,
- a reduction from 20 to 30% of the initial weight of the waste,
- a reduction to about 10% of the initial volume,
- recovery of metals,
- formed dross is not hazardous waste and can be used as a building material.

Disadvantages:

- high investment costs;
- waste from the purification of exhaust gases,
- large amount of solid process residues [11].

3.3. Co-incineration in cement kilns

Cement kilns are the leading among other installations, due to Directive 2000/76/EC are relatively the easiest and fastest to take, wide group co-waste. In Poland so far there are not too many examples proving this statement. This is proved by cement plants in the European Union and

it is expected that their example will soon follow the national cement plants [12].

Cement kilns are a viable and interesting alternative to take the thermal treatment of wide group of waste. The use of co-incinerating waste cement kilns is conducive to a number of conditions. These include, among others: implemented into Directive 2000/76/EC. They explicitly define the emission standards and process requirements related to the implementation of the process of co-incineration in cement kilns. Presented in the national strategy for waste management need to use thermal conversion processes for the disposal of a significant municipal waste stream, it is also possible through the co-incineration in cement kilns. The specific atmosphere and high temperature are characteristic for clinker burning process, so this is why in cement kilns is possible, much easier than in other systems to maintain the legally required emission standards and process requirements. The directive also does not omit the basic conditions which results from the definition of co-incineration of waste. Cement kilns due to the characteristic features of extending on them processes belong to this group of installations, which are able to comply with the law to take co-incineration of waste, fulfilling very sharply defined requirements for emission standards and parameters of processes [12].

Energy recovery in cement plants by co-incineration is produced from waste and it is completely safe and environmentally friendly process. For the alternative fuels from energy recovery were created special installations and warehouses. Preheated to a temperature of approx. 1450°C clinker makes that in rotary kiln chamber into which the fuel goes, with continued high gas, temperature up to 2000°C. Gases produced by the co-incineration of alternative fuels are staying in these conditions for

approx. 10 seconds. Efficient combustion and neutralization of harmful substances provides additional high (redundant) oxygen content in the furnace chamber and the fuel remaining in an alkaline environment. All these factors prevent the formation of hazardous substances produced by incomplete combustion of waste, especially toxic dioxins and furans. Technology that uses fuel from waste in cement kilns is waste-free. Solid combustion products (i.e. ash, slag) are mineralogically incorporated in the clinker. In addition, used in new generation cement plants high efficiency filters guarantee a reduction of emission of gases and dust to the level set by company standards, much stricter than the requirements of the European Union. Cement plants use fuel only from certain waste. The fact that in rotary kilns prevail favorable conditions for co-incineration alternative fuels, does not mean that in the process of cement production, you can use any waste. First, improper management of hazardous waste could constitute a danger to the environment. Secondly, the use of the wrong fuel components (i.e. PVC with high chlorine content) could lead to the destruction of the ceramic furnace lining or reduce the quality of the produced cement. Therefore the use of alternative fuels takes place under strict control and is always preceded by studies of the impact of raw material for cement clinker, furnace installations and environment [13].

3.4. Co-incineration in power equipment

There are many technologies for energy use from biomass, eg. using the existing boiler units fired by coal. Due to the way of the biomass portioning to the boiler co-incineration technology can be divided into:

- A direct co-incineration involving the simultaneous combustion of a mixture of coal and biomass fuel in one chamber, indirect co-incineration includes biomass combustion in the front of the hearth. The enthalpy of produced exhaust gases is used in the combustion chamber, wherein the heating surfaces are built either directly as a heating medium in the heat exchangers. The second case concerns the gasification or pyrolysis of biomass in the gasifier. The resulting gas is directed into the combustion chamber of the boiler, where it is burned in the burners and gas.
- Co-incineration involves in the same time the combustion of biomass in a separate boiler and sending produced in the steam or hot condensate to separate in coal boiler.

Despite the obvious advantages (such as the simplicity of the process, lower emissions of CO, NO_x and SO_2 and almost neutral CO_2 balance), a direct co-incineration of biomass and coal in power boilers raises a number of difficulties. They are related primarily to the physicochemical properties of the biomass significantly different from the coal burned in the power boilers. The differences are:

- the higher moisture content of the the raw biomass, which adversely affects the efficiency of the combustion process,
- higher content of volatile matter changing the conditions for ignition and combustion,
- lower calorific value of the raw biomass,
- significant differences in the quantitative composition (qualitative chemical composition is similar),
- two different residence time of fuel in the combustion chamber resulting from the large difference in particle density biomass and coal.

Other restrictions for biomass co-incineration in power boilers are associated with problems:

- logistic - It is estimated that in the climatic conditions of our region of Europe, biomass plantation area of 1 km^2 will produce annually amount of dry plant mass, sufficient to power the system (powered only biomass) with a capacity lower than 300 kW. Power plants with a capacity of more than 30-40 MW require a fuel plantations with areas of 100 km^2. Retrieving the quantity of biomass is problematic.
- economic - Estimates show that the increase of 1% of the biomass with a moisture content of 40-60% in a fuel stream fed to the boiler in order to co-incineration with coal causes 0.5-1% decrease in boiler efficiency. Compensation of this size requires an increase in the amount of chemical energy derived from fossil fuels, thus reducing the beneficial effects of co-incineration.
- technical - Co-incineration of biomass increases the intensity of a number of negative processes that occur during combustion of fuels such as:
  - deposition of granular materials on the heating surfaces of heat exchangers,
  - low- and high-temperature corrosion,
  - the emission of undesirable byproducts in exhaust gases and ashes, related mainly to the frequent change in the composition of petrol and its fluctuations.

The concept of renewable energy production in the process of co-incineration of biomass and coal is technologically simple, but it is the worst from the point of view of the quality of the use of biomass energy. It seems reasonable to use such technology to convert biomass

which leads to an increase in the degree of utilization of the energy without causing a reduction in thermodynamic efficiency of the cycle [14].

3.5. Combustion in fluidized furnaces

Fuel combustion in a fluidized bed is one of the methods for emission reducing of SO_2 and NO. The comminuted fuel and sorbent are added into the combustion zone of the boiler, where together with inert material (i.e. sand) are forming a bed. The combustion of fluid used for a continuous stream of the exhaust air or oxygen to ensure adequate turbulence, thereby achieving a state of suspension in the purge gas stream. The bed then behaves like a fluid and can be described as a fluidizing. Continuous mixing of the particles of the bed allows for complete combustion of fuel and ensures the maintenance of uniform temperature in the combustion zone. The heat of combustion is partly discharged by a pair arising on the boiler tubes passing through the bed. The bed materials not only provide heat transfer to the boiler tubes, but also bind sulfur dioxide. In this method, for binding of emitted sulfur during the combustion, are used two basic absorbents, i.e. limestone ($CaCO_3$) and dolomite ($CaCO_3MgCO_3$). The first step is the calcination of the sorbent, a result of which are formed CaO, MgO and CO_2, wherein the released carbon dioxide increases the porosity of sorbent, thereby increasing a surface area. The disadvantage of this method is incomplete reacted sorbent. The produced CaO and MgO are not completely used, that is due to the fact that the volume of moles of $CaSO_4$ and $MgSO_4$ is higher than in the case of CaO and MgO, so that the pores of the oxide particles, calcium and magnesium sulfates are covered with a layer which prevents the full utilization of the sorbent. The efficacy of the sorbent is determined

not only by the kinetics of the process, but also it is physical and chemical properties.

The advantages of waste incineration in fluidized bed boilers:

- simplification of the coal supply system,
- the possibility of combustion of low quality;
- the possibility of flue gas desulphurization in the boiler,
- reduction of NO_x emissions due to the low temperature in the furnace bed.

3.6. Thermal destruction in microwave devices

An alternative to combustion of waste is the thermal processing using microwaves. To a microwave destruction of industrial waste including hazardous are mainly used devices with a capacity of 50 kg / h. Typically, the technological process consists of three stages: the introduction of waste into the loading chamber, a microwave anaerobic disintegration of organic material in the temperature range 250 - 3500°C and the fragmentation of the residue on granules suitable for depositing on municipal landfill. This technology allows obtaining non-identifiable sterile microbiological residues. In typical construction embodiments of waste are placed on cardboard trays. Once can be entered up to approx. 50 kg of waste. After closing all chambers, they are filled inside with nitrogen and then the power is turned on for magnetrons producing microwaves. The photon energy generated by the magnetrons is selected by a program that controls the weight of the waste is destroyed and the temperature inside the reaction chamber. The principle of microwave waste destruction consists of the transfers of photons energy by molecules to the organic substances contained in the waste, so that the initial vibration

occurs, which is the result of dissociation to a smaller particles. The reaction progresses further, that the organic compounds which are solids are forming to a light organic compounds in the gas phase. Reaction residues gases are leaving installation through the treatment system and are discharged into the atmosphere. Other, not decomposed, reduced (charred) organic substances remain and after the thermal process takes its fragmentation. Powdery, homogeneous residue is conveyed pneumatically into carton boxes, which, together with the contents are exported to the municipal landfill. The whole cycle lasts from 50 - 90 minutes depending on the mass and composition of the waste. Total, daily plant capacity is approx. 700 kg assuming a 16 hour (two-shift) time. The intensity of microwave radiation on the outside of the device is controlled by the safety systems. Threshold alarm systems disabling power magnetrons were set at a level well below the current harmful to health. Clearly it must be stressed that the installation does not require auxiliary power fuels as in the case of incineration. It does not require power or natural gas or fuel oil. Arising from decomposition products at a temperature of about 2000°C may take about 10 minutes to lower temperature below 1000°C in order to be reduced in size. The cooling process takes place without the use of cooling media. It should be emphasized that the process is flameless means that there is no need to receive a large amount of heat. This significantly reduces investment and operating costs of the device. The big advantage of microwave device is the possibility of an immediate shutdown in the event of a power failure or malfunction of any system. In this case, the material is destroyed in the chamber magnetrons under an atmosphere of nitrogen while the fault exists and can then take place and to enable the device to complete the process

(even several days). In terms of environmental nuisance installation microwave are a lot of competition incineration as a remnant of the thermal process contains much less pollution. For a major advantage of the process of the microwave in comparison to the combustion is that the process is at temperatures below 3000°C and under an inert atmosphere. Such conditions prevent an overlap of many chemical reactions, which results in the formation of highly toxic chemical compounds. Such reactions occur during combustion at temperatures above 3500°C in the presence of oxygen required for combustion. In the process of the microwave waste destruction such a reaction does not occur, moreover, under the influence of microwave radiation compounds decompose rather than synthesis. There is no need to remove these pollutants by methods of adsorption on solid sorbents as incinerators, where it remains the problem of disposal of used sorbents. There is also no need to remove nitrogen oxides, since the process has a low temperature and takes place in an atmosphere of pure nitrogen. Under such conditions, the nitrogen oxides are not formed. For this reason, SO_2 and CO are present in the reaction gases at low concentrations [9].

Microwave systems have simple but effective purification systems of the reaction gases with the use of wet absorption in an alkaline aqueous solution of NaOH. Due to the very low concentration of particulate matter and heavy metals in the treated waste, the waste water is also free from such substances. In the process is created approx. 20 dm^3 (0.02 m^3) of the sewage in an hour, which is significantly less than during the wet flue gas cleaning of waste incineration [9].

3.7. Plasma thermal destruction

Plasma is a highly ionized gas in which there are normal molecules, ionized atoms and electrons, but the whole volume occupied by the plasma of a "global" point of view it is electrically neutral. Plasma is often called the fourth state of matter after solid, liquids and gases. The plasma is electrically conductive, and electrical resistance, unlike metals, it decreases with increasing temperature. Because of the temperature of the plasma is divided into:

- cold plasma (4 000-30 000 K) produced in plasma torch,
- hot plasma (above 30 000 K) occurring inside stars or during nuclear explosions.

The possibility of obtaining high temperatures in the stream of plasma (low temperature plasma) offers the possibility of destruction of the waste more efficiently compared to a conventional combustion because the plasma generated by an electric field raises the temperature to a much higher value (as 8 000°C) than the flame in furnaces boiler. Due to the high temperature and high energy density plasma, the process of destruction is very high, what determines the high efficiency waste incineration. Supply of the oxidizing agent into the reactor provides effective oxidation of waste in the plasma zone [15].

Plasma technology for treatment of waste as one of a few has huge opportunities of disposal all sorts type of waste ranging from biodegradable materials and ending with heavy metals, dioxins, furans and other substances that are emitted during combustion in conventional incinerators. In industrialized populations, this technology is slowly entering into force and replaces the conventional disposal plants. They constitute success both

in environmental protection and technical success. Technology is a significant alternative to conventional incinerators. Modern research has shown that incinerators created in Europe and America in the 70s are outdated and are many threats to the environment. The most important include:

- the presence of toxic substances in dust and ashes,
- emission to the atmosphere of harmful substances such as HCl, heavy metals, nitrogen and sulfur oxides, dioxins and furans,
- emergence of toxic wastewater in the process of cooling and flue gas cleaning.

It is mainly used for low-temperature plasma within its temperature 2000 - 30000 K no clearly marked by the limits of the interval. This technology in the first place bets on the possibility of burning all kinds of hazardous waste and extremely dangerous, which practically cannot be eliminated from the process of paper production and combustion in conventional incinerators. The technology has also of great importance when it comes to recovery of non-ferrous metals, particularly those most valuable [16].

Advantages:

- large processing capacity of approx. 170 kg/h with opportunities to work 23h/day,
- the total destruction of hazardous waste 99.9%,
- a significant reduction in pollution of waste gases significantly below the permitted standards (content of hydrogen chloride HCl significantly below <50 mg/m^3, the contents of CO_2, CO, H_2O - sparse),
- disposal of waste chlorine does not cause the formation of dioxins and furans,

- high-performance processing using a relatively small size system,
- the possibility of achieving very high temperatures ranging from 2,000 to 10,000 K with a high flexibility,
- ease of use and low thermal inertia equal to several seconds,
- providing a a concentrated energy independently of natural gas.

Disadvantages:

- relatively high power consumption equal to about 2 MWh/ton of waste, which increases the cost of operating the system,
- there is a possibility of emission radio-electric generated in the arc for electrical work within the plasma.

Currently, plasma technology for treatment of waste found its use mainly for the processing of hazardous materials. However, it is forecast that it also applies to the of disposal other wastes. It is a slow process and requires a global view on the management of waste and recycling material. The method of plasma should be in addition to existing today, other methods of disposal and recycling. Only in this way can one type of waste sublimate other, more dangerous to be transported to the installation of plasma [16].

4. Summary

The problem of municipal waste management is still growing. This is due to an increase of their amount and of the legislative conditions, posing increasingly less able to land in the agricultural use or storage. It is more and more necessary to find new solutions, including thermal. The combustion of waste, such as combustion of conventional fuels is the process inherent to the formation of a variety of toxic or dangerous to human life and the environment substances. In the case of incineration

the degree of danger to the environment depends on many parameters, in particular, the inhomogeneous alternating physical and chemical substrates. However experience of operating the most modern waste incineration plants show that, it is possible to significantly improve the ecological safety of the combustion process. Currently, it is possible to restrict the occurrence of contaminants to a minimum or trace quantity, depending on the construction of incineration plants. Another important aspect of the operation of a waste incineration plant is the possibility of recovering heat from the combustion process. Depending on the needs of the use of energy produced and the calorific value of the waste (min. 5800kJ / kg), it is possible the functioning of the installation of thermal utilization, as a local heating plants, power plants or heat-power plants.

A comprehensive system of thermal waste associated with certain capital expenditures and operating costs. Comparison of the amount of investment of building incinerators in Europe is very difficult, because each type of incinerator entails other costs. Municipal waste management in Poland increasingly accelerates, therefore, to meet its requirements, including the disposal of waste is necessary to introduce and test new methods aimed primarily at achieving energy and material recycling.

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Possibility assessment of zeolite activation by using chemical reducers

Keywords: *treatment of groundwater, catalytic mass, iron, presence of iron in the water*

Summary: Groundwater is the main source of drinking water for human being. It is mainly characterized by the high quality, however the presence of iron and manganese has always constituted the problem. Natural sources of these elements in the ground water are elution processes washing them out from rocks and ground. For the septic reasons it is necessary to remove iron and manganese compounds. Apart from that, they cause unpleasant taste of water or can create sediments in dark brown (manganese) or brown-red (iron) sludge. Their removal is done by oxidation firs. It is run on suitable beds, where simultaneously filtration and adsorption take place. The most popular are sand beds, which are often enriched in other materials. Currently, more effective materials as bed media for iron and manganese are searched for their removal.

The object of this paper is one of these materials, zeolite. It has a porous structure, which makes that zeolite is the perfect adsorption material. The aim of this paper is analysis of usefulness of zeolite as an adsorption material for iron and manganese removal.

1. Introduction

Ground water is generally considered as the main source of water supply for population. Introduction of Polish regulations on the quality of water for human consumption (Regulation of the Minister of Health of 29 March 2007, Dz.U.2007, No. 61, item. 417) effects level reduce of permitted content of iron and manganese according to the value

of 0.2 mg Fe / dm^3 and 0.05 mg Mn/ dm^3 and ammonia to 0.5 mg NH_4^+/dm^3. This contributes to technological problems in many stations treatment of these waters.

Groundwater treatment technology is very simple. Pollution usually occurring in these waters containing iron and manganese usually don't cause big problems and can be easily removed in the traditional systems of aeration and filtration. Treatment process is more complicated when iron and manganese are also present as well as other impurities such as ammonia nitrogen. To intensify the process of oxidation of iron and manganese, chemical oxidation with chlorine, chlorine dioxide, ozone or potassium permanganate are more often added. In practice, the safest and most commonly used oxidant is potassium permanganate ($KMnO_4$), which is dosed into the water before filters [1].

The effective removal process from water of iron and manganese proved filtration by chemically active mass. Among the oxidative beds we find natural ore manganese containing which depends on the origin from 60 to 95% of MnO_2 (mass: G-1, FILOX, Pyrolox, Defeman) and beds which grain is covered coated manganese dioxide (MnO_2) during activation using $KMnO_4$ (mass MZ -10 and clinoptilolite). Technology with the catalytic masses allows high-efficient removal of iron and manganese and to some extent ammonia. Compounds of iron and manganese, ammonia and excessive hardness of the water also remove the mass of the zeolite Crystal-Right 100.

The main aim of this paper is analysis of usefulness of zeolite as an adsorption material for iron and manganese removal.

2. Characteristic features of the zeolite

The increased demand for water treatment and water protection against pollution enforce the search for more effective, but also low-cost and environmentally safe solutions. Zeolites are referred to as hydrated aluminosilicate. They have porous structures, which are naturally occurred materials. Zeolite is the main class of hydrated aluminium silicates found in volcanic rocks. This material in its structure includes a system of channels and chambers, which owes their unique properties. Among them, the ability of ion exchange, adsorption, molecular-sieve and catalytic [2,3] can be recognized.

Adsorption properties and porous structure of these minerals indicate the possibility of their use as adsorbents of organic compounds. Zeolites are called minerals in the 21st century, because not only they are easily available but also have adsorption capabilities and low price.

In the World there are about forty- five natural types of zeolites, among which the most occurring and used are:

- Clinoptilolite $Na_6[(Al_2)_6(SiO_2)_{30}]*24H_2O$
- Chabazite $Ca_2[(AlO_2)_4(SiO_2)_8]*13H_2O$
- Modenite $Na_8[(AlO_2)_8(SiO_2)_{40}*24H_2O$.

They are formed in a relatively low temperature in geologic environments.

In the group of zeolites, synthetic zeolites deserve special attention, especially those that can be produced from waste materials e.g. fly ash [4]. The material obtained in this way is characterized by the low cost production, durability, chemical inertness, non-flammability and large adsorption capacities. These qualities are characteristic for top-class

absorbers. Properly selected operating conditions of the synthesis process allow to obtain different types of zeolite structures. They have a wider range of properties and larger cavities than their natural counterparts. First production was in 1950s. Currently, more than 100 different types of zeolite have been made in complicated chemical processes. All in all, the production of synthetic zeolites is 12,000 ton.

Zeolites are manufactured in a number of ways: one important technique involves mixing sodium, aluminium, and silica chemicals with steam to create a gel. Another technique uses kaolin clay which is heated in a furnace until it begins to melt, then chilled to powder. This powder is mixed with sodium salts and water, aged and heated [5].

The atomic structures of zeolites are based on three-dimensional frameworks of silica and alumina tetrahedra, that is, silicon or aluminium ions surrounded by four oxygen ions in a tetrahedral configuration [5].

Zeolites are widely used in environmental protection technologies from water and wastewater treatment (removal of ammonium ions, radioactive elements, heavy metals, petroleum pollutants) to adsorb water and gas, agriculture and various industries.

In the construction industry, zeolite tuffs can be used for the production of cement or as a supplement to the Portland clinker. Zeolites are widely used as catalyst supports in petrochemical, in the course they include steam cracking, alkylation in the processing of oil and natural gas.

Adsorption properties of zeolites are commonly used for drying and purification of gases e.g. Removal of H_2S, methane, CO_2, N_xO_Y, H_2S and water vapor from natural gas and the gas separation and hydrocarbon.

Natural zeolites proved to be "ecological clean" in comparison to the synthetic zeolites (dominant in detergent sector). It mainly results

from their high capacity, high speed, the preferential complexation of calcium ions in aqueous solutions at elevated temperature.

Synthetic zeolites, replacing fillers in detergents were criticized because they cause pollution of canals, rivers and beaches. At the same time, intensive research is conducted on the usefulness of natural zeolites for detergents. In the pharmaceutical industry clinoptilolite is used for polishing the fluoride toothpaste and drug stabilizing the digestive system. The special case of the use of zeolites is drying and cleaning air and oxygen in the spacecraft cabins and masks, thanks to which astronauts breathe. Unfortunately, not all zeolites can be considered completely safe for users' health. Zeolites with fiber structures and in rigid fibers, such as erionite, natrolite, which ultimately assigned carcinogenic should be excluded from direct use.

In agriculture, zeolites have a variety of uses as feed additives, fertilizer and soil conditioners. Plant nutrients which settle in channels of a zeolite structure allow slow transfer to the soil and prevent too leaching rapid.

Silicates play particularly important role in protecting the environment. In the area of renewable energy, zeolites can be used as heat exchangers. They participate in the absorption and release of solar energy.

In recent years, the growing threat of resources hydrosphere aroused and technologists hope to use wider properties of these silicates for water and wastewater treatment.

3. Methods of Iron and Manganese Removal

Iron and manganese occur in dissolved forms as single ions (Fe^{2+}, Mn^{2+}) or in undissolved higher forms mainly as $Fe(OH)_3$

or respectively as $Mn(OH)_4$. They can also be present in colloid form (bound to humic substances). The form of their occurrence depends on oxygen concentration, solubility of Fe and Mn compounds in water, pH value, redox potential, hydrolysis, the presence of complex-forming inorganic and organic substances, water temperature and water composition (e.g. CO_2 content). Adverse effects of higher Fe and Mn concentrations in drinking water can be summarized as follows: iron (II) and manganese (II) ions are oxidized to higher forms in a water distribution system and this results in the formation of hydroxide suspensions causing undesirable turbidity and colour of water. Next the result of the presence of iron and manganese is the way to develop bacteria in water supply system which causes the change in water quality (smell) and bacterial growth in pipes. Following the above-mentioned facts, higher concentrations of iron and manganese in water cause technological problems, failure of water supply systems operation, water quality deterioration. Apart from that, in water with slightly higher concentrations of oxygen, they form undesirable incrustations which result in the reduction of cross-section pipe flow [6].

The principle of most methods used for iron and manganese removal is that originally dissolved iron and manganese are transformed into undissolved compounds that can be removed through single-stage or two-stage separation. Oxidation and hydrolysis of these compounds are done under strict conditions with respect to water properties and type of equipment for iron and manganese removal.

Single-stage water treatment (filtration) is designed for iron and manganese concentrations to 5 $mg \cdot l^{-1}$, and the two-stage treatment (settling tanks or clarifiers and filters) is used for water with iron and manganese

concentrations higher than 5 $mg \cdot l^{-1}$. In case of water, it contains higher concentrations of Ca, Mg, and CO_2 (eventually H_2S), that's why aeration is done before settling or filtration. Removal of Fe and Mn from groundwater and surface water can be done by several methods:

- oxidation by aeration,
- removal of Fe and Mn by oxidizing agents (O_2, Cl_2, O_3, $KMnO_4$),
- removal of Fe and Mn by alkalinization (by adding the lime),
- contact filtration for removal of Fe and Mn,
- removal of Fe and Mn by ion exchange,
- removal of Fe and Mn using membrane processes,
- removal of Fe and Mn using biological filtration,
- removal of Fe and Mn using in situ method.

Fe^{2+} and Mn^{2+} oxidation rate as well as hydrolysis of emerging oxides of higher iron and manganese oxidation forms in groundwater depend on the pH value. Various graphic dependencies of these relationships with respect to oxidation time are listed in literature. The pH value should be equal or greater than 7 in removal of iron from groundwater whereas for removal of manganese without catalyst the pH value should be equal or greater than 8 [7].

Removal by using the oxidized film on grains of filter medium is one of the methods for elimination of dissolved manganese. The film is formed on the surface of medium filter by adding permanganate potassium (not only KMnO4 but also other strong oxidizing agents). The film serves as a catalyst for the oxidation process. Grains of filter medium are covered by higher oxides of metals. In this case, it is related to special filtration so-called "contact filtration" – filtration by using manganese filters. The oxidation state of the film of MnOx (s) filter medium

is important in removal of dissolved manganese. Manganese removal efficiency is a direct function of MnOx (s) concentration and its oxidation state. The films with different ability to remove dissolved manganese from water are formed on the surface of various filter media [8-9].

Natural or synthetic zeolite can be used as a filtration material for removal of iron and manganese from water. Birm, Greensand, Pyrolox, are the most frequently used materials in filtration. Natural or synthetic zeolite can be used as a filtration material for removal of iron and manganese from water [9].

4. Methods

Analysis was carried out at The Bialystok Technical University, in the Department of Technology in Engineering and Protection Environmental. Research was based on the activation of zeolite mass by using potassium permanganate. The analyzed adsorbent was zeolite with granulation coarse-grained 4,0-8,0 mm and fine-grained 0,5-1,0 mm. Figure 1 presents zeolite with granulation fine-grained 0,5-1,0 mm.

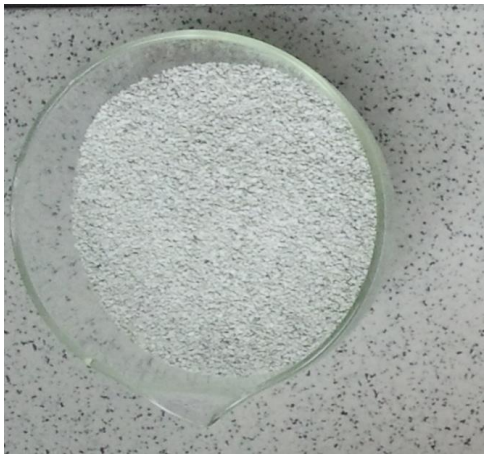

Figure 1. zeolite with granulation fine-grained 0,5-1,0 mm

Source: Own materials

Figure 2. Zeolite with granulation coarse-grained 4,0-8,0 mm

Source: Own materials

For the preparation of test samples, 1.5 kg of each deposits was measured. Next, potassium permanganate solution was prepared, which deposits were flooded. The expected time activation samples was 3,5,7 and 9 weeks. Figure 3 shows flooded deposits.

Figure 3. Probes of zeolites with manganese solution

Source: Own materials

The precipitation was carried out by:

- 5% solution NaOH
- 5% solution $FeSO_4$
- 5% solution $FeSO_4 *7H_2O$
- 5% solution $FeCl_2$

Each sample was left for 2 hours, followed by addition of 10 g of $KMnO_4$. The next step was drying deposits at 50^0C. All samples were placed under running water to flush out remaining reagents and washed out over the precipitated MnO_2 layer. At the end the above described research was conducted.

5. Results and discussion

Table 1 presents research results. It focused on showing the amount of the deposited layer of MnO_2.

Table 1. Test results

Filter material	**Reducer**			
	5% solution NaOH[1)]	**5% solution $FeSO_4$[2)]**	**5% solution $FeSO_4 *7H_2O$[3)]**	**5% solution $FeCl_2$[4)]**
Layer MnO_2 on the zeolite with granulation 0,5-1,0 mm	1.43 g/m s.m.	0,99 g/m s.m.	1,05 g/m s.m.	1,17 g/m s.m.
Layer MnO_2 on the zeolite with granulation 0,5-1,0 mm	0,77 g/m s.m.	0,98 g/m s.m.	1,21 g/m s.m.	1,08 g/m s.m.

Source: Own source

1) Time activation- three weeks
2) Time activation- five weeks
3) Time activation- seven weeks
4) Time activation- nine weeks

As we can observe from the above table the largest amount of MnO_2 was laid after three weeks of activation on zeolite fine-grained whereas the least amount of MnO_2 was laid after three weeks of activation on zeolite coarse-grained. Figure 4 and 5 present graphs that show the dependence of the deposited layer of MnO_2 from the time activation.

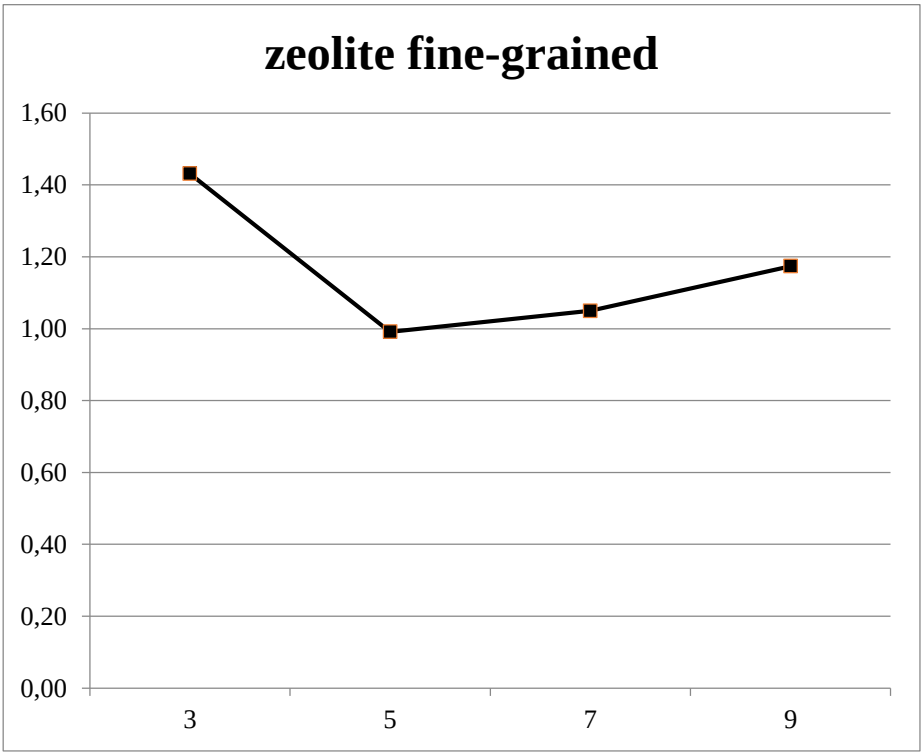

Figure 4. Dependence of deposited layer MnO_2 on zeolite fine-grained from the time of activation
Source: Own materials

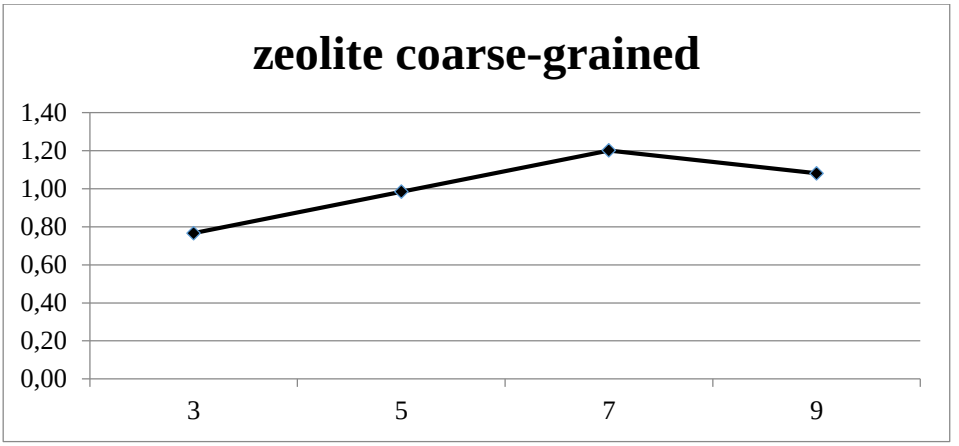

Figure 5. Dependence of deposited layer MnO_2 on zeolite coarse-grained from the time of activation

Source: Own materials

The research allows to obtain material on the grains laid down on the active layer of MnO2. As a result, it will be used in further studies for the groundwater treatment from compounds of iron and manganese. Kaleta and others (2009) claim that the filtration of groundwater through the activated mass allows the effective removal of Fe and Mn. In addition, they note that after filtration the lowered content ammoniacal nitrogen, color and turbidity are visible. All indicators will be tested in the following phases of experiments, which include research on crafted water of these compounds.

6. Conclusion

1. Deposits laid down on the layer of oxidizing manganese dioxide allow deposit's activation and use it to process iron and manganese removal.
2. The experiment shows that more susceptible to zeolite activation was fine-grained because more MnO is deposited on it.

3. It also notes the impact of time activation for the content of MnO_2 in the fields. For zeolite coarse-grained, the best time activation was 7 weeks, for fine-grained the best time was 5 weeks.
4. The most effective used reducer was NaOH.

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Natural conditions of organization an environmental monitoring in the Gniezno District

Keywords: *environmental monitoring, environmental protection, pollutions*

Summary: The natural environment of the Gniezno District is undergoing intensive changes. Constant transformation, both natural and anthropogenic, causes the evolution of the natural environment of the region. The Gniezno District, possessing both environmental and historical value, is undergoing constant changes. At the same time, the environment of the area is one of the least monitored among the districts of the Wielkopolska Province. This, as well as the abundance of industrial activities and national communication trails, leads to the conclusion that pursuing the development of a network monitoring the natural environment of the District is necessary. The main goal of this work is to evaluate the current state of the environmental monitoring in the Gniezno District and suggest changes in the monitoring program.

1. Introduction

11.1. Theoretical basis

The natural environment of the Gniezno District is undergoing intensive changes. Constant transformation, both natural and anthropogenic, causes the evolution of the natural environment of the region. Climate change and increasing human impact influence the individual components of the environment, as well as certain types of landscapes. The components of the environment vary with respect

to their vulnerability and the time they take to react to both natural and anthropogenic stimuli. Local geoecosystems are threatened by the presence of the large agglomeration of the Gniezno District and the neighbouring towns, agricultural lands and companies of varying profile, which pollute the air, soil, and water. Intensive traffic and tourist activity also play a large role in the transformation of the natural environment in the region.

The Gniezno District, possessing both environmental and historical value, is undergoing constant changes. At the same time, the environment of the area is one of the least monitored among the districts of the Wielkopolska Province. This, as well as the abundance of industrial activities and national communication trails, leads to the conclusion that pursuing the development of a network monitoring the natural environment of the District is necessary.

The contemporary Polish natural environment undergoes transformations that stem from both secular variation and increasing human impact. The changes encompass both the individual components of the environment and geoecosystems as a whole [1]. The geography of the region, due to the extent of human influence, should be monitored with particular attention paid to its anthropogenic aspects.

11.2. National Environmental Monitoring

National Environmental Monitoring was created in accordance with the National Environmental Protection Inspectorate Act of 20 July, 1991 [2]. Its aim is to provide reliable information about the condition of the environment. The Environmental Protection Law Act of 2001 [3] strengthened the role National Environmental Monitoring, defining

it a system meant not only to diagnose the natural environment, but also to gather, process, and distribute information about it.

The National Environmental Monitoring System consists of three blocks:

- the 'condition' block comprises activities connected to the acquisition, gathering, analysis and distribution of information about substance content and other factors that characterise the condition of the individual components of the natural environment,
- the 'pressure on environment' block enables the acquisition of data pertaining to the sources and volumes of substances released to the environment. It is mainly focused on the information on emissions gathered from the administration, public statistics and the Environmental Protection Inspectorate.
- the 'evaluation and forecasts' block is devoted to evaluation and prognostics, as well as cause-and-effect analyses, which relate the current condition of the environment to the factors that influence it, mostly results of human activity.

A prominent part of the National Environmental Monitoring System is the network of Integrated Environmental Monitoring (geoecosystem monitoring), conducted by assigned base stations representative of the neighbouring areas, and the so-called “specialised monitoring.” Specialised monitoring include: meteorological monitoring, surface waters monitoring, underground waters monitoring, ground surface monitoring, biosphere monitoring, and extreme geological events monitoring, run by Environmental Protection Inspectorates in each Province in cooperation with the Institute of Meteorology and Water

Management, the Institute of Plant Protection and the National Research Institute.

12. Study area

The Gniezno District is a unit of territorial administration in Greater Poland Voivodeship, west-central Poland. The district covers an area of 1254 km^2. It is a very characteristic area from the environmental and economic point of view. Geographically it belongs to the mezoregion Gnieźnieńskie Lakeland [4]. Gnieźnieńskie Lakeland lies in the young glacial zone connected with leszczyńska and poznańska phases of Baltic Glacial [5]. The climate of this mezoregion is very similar to the climate of central Poland [6]. According to the climate regionalization from Gumiński [1948] it belongs to the province VII called "the middle one" [7].

Figure 1. Forests in the Gniezno District

Source: www.geoportal.gov.pl, author's work

According to the surface and underground waters it is known, that the pace of water circulation is rather slow [8]. It is caused by a large number of lakes. In the area of Gnieźnieńskie Lakeland occur over 30 lakes. From this 30 years in the Gniezno District occur: Lednica Lake, Niedzięgiel Lake, Kamienieckie Lake, Ostrowickie Lake, Popielewskie Lake, Wierzbiczańskie Lake, Piotrkowskie Lake, Jelonek Lake, Świętokrzyskie Lake, Winiary Lake, Białe Lake, Strzyżewskie Lake, Kłeckie Lake, Gorzuchowskie Lake and other small water reservoirs. There are also rivers: Wełna, Mała Wełna, Wrześnica, part of the river Główna and also many shorter water coursers and drainage ditches [9].

Forests covers 14,5% of the area of the Gniezno District (fig. 1). Over 70% of the area is covered by agricultural lands [10]. The land use structure of the Gniezno District is connected with the good quality of soils and its use for agriculture.

Table 1. Characteristic of the population of the Gniezno District

Name of the teritorial unit	Area in km^2	Population		Population density persons/ km^2
		In general	women	
The Gniezno District	1.254,3	140.109	71.614	111,70
City communes				
Gniezno	40,9	70.128	36.491	1.714,62
City-country communes				
Czerniejewo	112,00	6864	3385	61,29
Kłecko	131,7	7636	3854	57,98
Trzemeszno	174,8	13.981	7050	79,98
Witkowo	184,4	13.490	6792	73,16
Country communes				
Gniezno	178,0	8241	4115	46,30
Kiszkowo	114,6	5289	2596	46,15
Łubowo	113,4	5177	2598	45,65
Mieleszyn	99,2	4000	2055	40,32
Niechanowo	105,3	5303	2678	50,36

Source: [10]

Socio-economic situation of the Gniezno District is positive. Economy and agriculture are in good shape. The demographic trends are similar to the common trends in Greater Poland (tab.1).

The Gniezno District is a specific area, where the natural resources and a highly developed economy and agriculture need to coexist (fig. 2). This situation makes a huge challenge for the local government, ecologists and environmental protection specialists.

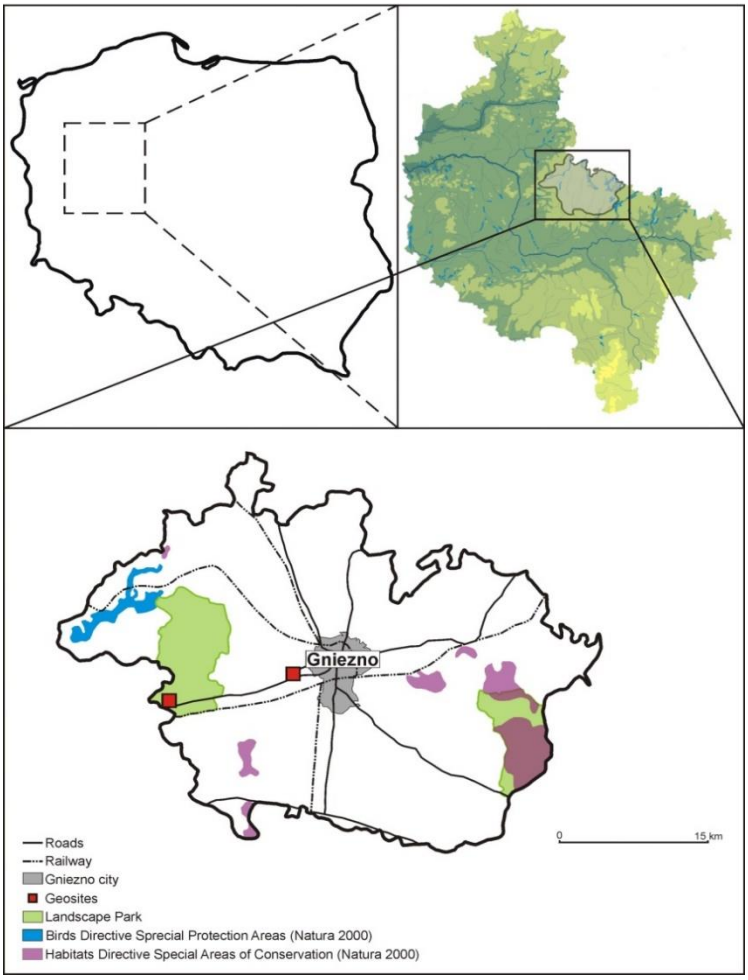

Figure 2. Study area with protected areas (District Gniezno, Greater Poland)

Source: Author's work

13. Methods

Methods include:

- to work with cartographic material,
- to analyze results of the environmental monitoring conducted by The Provincial Environmental Protection Inspectorate in Poznań,
- to prepare and conduct a survey among the citizens of the Gniezno District.

14. Forms of environmental protection in district Gniezno

Gniezno County is covered with protected areas. Tab. 2 presents a specification of the categories of environmental protection.

Table 2. Forms of environmental protection in Gniezno County

Category of protection:	Name of the form:	Details:
Landscape parks	Lednica Landscape Park	The Park was opened in 1988 in order to preserve the unique terrains, which were the cradle of civilization on the grounds around Lake Lednickie. It's surface area is 7.652 ha and it is situated within urban districts such as Łubowo, Kiszkowo, Kłecko and Pobiedziska. It is the first ethnographic Landscape Park in Wielkopolska. The plains are rich in numerous moraines hills and postglacial lakes such as Lednickie, Głębokie, Sławno, Bachorce and Linie. The Park's highlight is Lake

		Lednickie with four islands.
	Powidz Landscape Park	The Park was opened in 1998 in order to protect natural and historical values. It's surface area is 24.600 ha and it is situated within urban districts such as Kleczew, Orchowo, Ostrowite, Powidz, Słupca, Wilczyn and Witkowo. The peculiar characteristic of the region is the existence of 17 postglacial lakes which are narrow, long and deep. There are two examples of the biggest and cleanest lakes in Wielkopolska: Lake Powidzkie and Lake Skorzęcińskie. Lake Czarne is very specific because of its vegetation. In the Park, there are 990 plant's species in 216 gatherings.
	"Puszcza Zielonka" Landscape Park	The Park was opened in 1993. It's surface area is 9.981 ha. There are pine forests with some deciduous trees. There are many protected trees in the Park including the oak on the route to Dąbrówka Kościelna. In the region of Dąbrówka Kościelna the wildlife reserve "Modrzewie Klasztorne" is a very characteristic feature. Just there, the oldest larch-pine forest in Wielkopolska grows covering the area of 6

		ha. Animals that live in the forests include deer, fallow deer, roe deer, wild boar, hare, fox, badger, marten, otter and beaver. There are also protected bird's species such as raven, black stork, crane. Among the birds of prey one may meet white-tailed eagle. The interesting elements of the landscape are ponds, which definitely add to the diversity of the forested surrounding.
Nature reserved	"Bielawy"	The entire area of the reserve is one complex with a total area of 20 ha. The object of protection in the reserve is a deciduous forest fragment of a natural communities which are rarely encountered in the region.
	"Wiązy w Nowym Lesie"	Overall reserve can be characterized as a deciduous forest which is a multilayer structure with the object of protection - the elm.
	"Modrzew Polski w Noskowie"	The main goal of protection in this reserve is polish larch.
Protected areas	"Powidzko-Bieniszewski obszar chronionego krajobrazu" eng. Powidz-Bieniszew protected area	The area was established in 1996 and it covers 46000 ha. One of the protected category of areas are rare species of orchids. The largest lakes in the area are: Powidzkie, Niedzięgiel, Suszewskie,

		Wilczyńskie, Bogusławskie and Ostrowickie.
Natural monuments	390 monuments	299 trees, 1 erratic block.
Ecological sites	Ecological site in Kiszkowo	It is a perfect refuge for a wildlife on the area of 120 ha. A great place for birds, also for rare species such as pelicans and gooses.
City and rural parks	44 parks	Parks beyond the historical significance also play an important ecological function. By enriching and diversifying the natural environment are often the only green lands on the treeless areas of the moraines.
Natura 2000 areas	PLB300006 – The Little Wełna Valley - Kiszkowo	The area includes several kilometer section of the valley of the Mała Wełna river with meadows, oxbow lakes, natural water reservoirs and fish ponds.
	PLH300026 – Gniezno Lakeland	This area has a very characteristic sculpture connected with many glacial forms. It is also known as a complex of lakes (Białe, Budzisławskie, Skubarczewskie, Czarne, Hutka, Kamienieckie, Kosewskie, Modrze, Niedzięgiel, Orchowskie, Ostrowickie, Powidzkie, Procyń, Rusin,

Natura 2000 areas		Salomonowskie, Słowikowo, Suszewskie, Wierzbiczańskie, Wilczyńskie, Wójcińskie).
	PLH300050 – Community "Kiszkowie Ponds"	The area covers a part of the valley of the Mała Wełna river and a couple of fish ponds build in the 80's. The ponds are characteristic because of temporary lack of water. It makes them hard to maintain in the economically point of view.

Source: [11], [12]

15. Current state of environmental monitoring in the Gniezno District

15.1. Air quality monitoring

The Provincial Environmental Protection Inspectorate in Poznań conducts the following surveys in the Gniezno District (fig. 3):

a) gas emissions in fuel combustion facilities with output exceeding 50MWt – one location – Przedsiębiorstwo Energetyki Cieplnej (Heat Supply Company, a thermal power plant) in Gniezno,

b) particle emissions in fuel combustion facilities with output exceeding 50MWt – one location – Przedsiębiorstwo Energetyki Cieplnej (Heat Supply Company, thermal power plant) in Gniezno,

c) annual concentration and one-hour maximum pollution (NO_x, NO_2, SO_2) - one location – Krzyżówka,

d) PM10 particle pollution – one location – Jana Pawła II street, Gniezno,

e) ozone content in the air – one location, Krzyżówka,

f) sulphur and nitrogen dioxide concentration in air, annual mean – one location – Lednogóra.

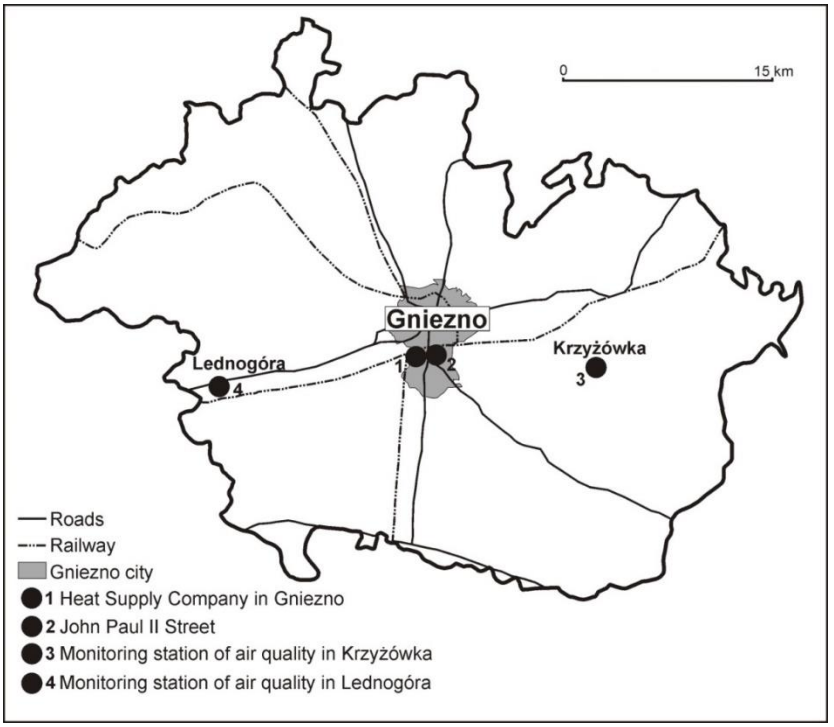

Figure 3. Locations of measurements points in air pollution monitoring in the Gniezno District

Source: Author's work

The data gathered during the emission measurements in those locations is then used to create reports about the state of environment in Wielkopolska in consecutive years. In 2014 air quality in the Gniezno District was good. Results of the air pollution monitoring in 2014 enabled to classify air quality in the Gniezno District to A category (the best category) in reference to NO_2, SO_2, CO, C_6H_6, PM2,5 particle, As, Cd, Ni, Pb, O_3. Only in reference to PM10 particle and benzo(a)pyrene results showed exceeding. For this pollutants the C category (the worst one) was

assigned. This results are typical for the whole Greater Poland Voivodeship [13].

The Provincial Environmental Protection Inspectorate in Poznań also conducts the Spot Emissions Inspection programme. Within this programme, pollutant emissions in production and service enterprises in individual districts and communes of the Wielkopolska Province are controlled. In the Gniezno District, 151 facilities are subject to this supervision. They are required to submit yearly pollution emission reports. Additionally, intervention inspections were also conducted as part of this project.

15.2. Noise level monitoring

In the Gniezno District noise level studies have been conducted twice, in 2010 and 2012. As part of this study, the Provincial Environmental Protection Inspectorate in Poznań investigated the conditions of particularly onerous noise pollution caused by traffic. In the Gniezno District, measurements have been taken on the national road No. 5, on the fragment that crosses the city of Gniezno. The measurements showed that the threshold which marks noise pollution as especially onerous for residential areas as well as healthcare and educational facilities was passed. In spite of that, the research has not been extended to encompass other stretches of the local road network. Results of the noise level monitoring in 2012 gave information about inconsiderable exceeding of standards. After changes in the law there are new standards and – n 2013 and 2014 – lack of noise level monitoring [13].

15.3. Water monitoring

Before 2014 the Provincial Environmental Protection Inspectorate in Poznań did not assigned sampling sites when it comes to water monitoring in the Gniezno District. The only piece of information made available by the Provincial Environmental Protection Inspectorate in Poznań regarding the area is a statement that water quality is satisfactory and that the chemical composition of the District's water bodies is good. In 2014 there were some measurements in three points connected with rivers: Mała Wełna and Gnieźnieńska Struga. The results showed, that the general state of the rivers is bad. The ecological indexes were moderate for samples from Mała Wełna and poor for the samples from Gnieźnieńska Struga. The chemical indexes for samples from Mała Wełna were good. There were no samples for chemical analyses from Gnieźnieńska Struga. These results are alarming because all monitored rivers flow through the protected areas. Also one lake (Wierzbiczańskie) was monitored – general quality of the water was classified as "good" [13]. In 2014 there were also made some measurements of the underground water (in one location – Witkowo). Results showed, that underground waters in this area are not threatened with pollutions from agriculture (especially pollutions connected with nitrogen).

15.4. Ground surface monitoring

The Provincial Environmental Protection Inspectorate in Poznań does not monitor the ground surface. At the same time it must be stressed that problems associated with soil and ground surface degradation do exist in the area of the Gniezno District.

15.5. Biosphere monitoring

As is the case of ground surface monitoring, the Provincial Environmental Protection Inspectorate in Poznań does not monitor the condition of the biosphere. According to the Bulletins of Environmental Protection issued by the environmental authorities, biosphere monitoring sites are yet to be created in the Gniezno District. The only organised facilities in the area used to observe biosphere are permanent observation sites for forest monitoring. Five observation areas have been created in the District: three located in the areas managed by the Gniezno forest inspectorate, and two in the areas governed by the Czerniejewo inspectorate. However, the latest monitoring report concerned year 2008 and the data was averaged over the entire country. It is, therefore, not possible to specify the characteristics of the forest stand in the Gniezno District.

15.6. Types of activities that may heavily influence the environment

Most of the industrial facilities and production sites in the District influence the condition of the area's air (Tab. 3). The main problem is the emission of gas and particles, as well as the creation and emission of onerous odours, affecting areas several kilometres around the facilities, depending on the direction of the wind.

Enterprises specified in Table 3 do not influence the waters of the area significantly. However, unsupervised and illegal waste dumping from private properties into local watercourses and reservoirs is an issue. Noise emission above the norm has not been registered for the enterprises in Table 3. Noise is, however, monitored only on special occasions. The following

communes are most susceptible to the influence of the above-mentioned facilities: Gniezno, Kłecko, Trzemeszno, and Witkowo.

Table 3. Most of the industrial facilities and production sites with potential influence on environment in the Gniezno District, based on sozological map 1:50 000 [14], [15], [16], [17], [18], [19], [20], [21], [22]

Lokalizacja obiektu (miejscowość, adres)	**Gmina**	**Rodzaj presji na środowisko (możliwe szkody środowiskowe)**	**Typ działalności**
Dąbrówka Kościelna	Kiszkowo	Emission of odours	Poultry farm
Kamieniec	Kłecko	Emission of odours	Cattle farming
Kłecko	Kłecko	Emission of odours	Poultry farm
Pomarzany	Kłecko	Emission of odours	Cattle farming
Sokolniki	Mieleszyn	Emission of odours, source of noises	Poultry farm
Bojanice	Kłecko	Emission of odours, source of noises	Swine farming
Przedsiębiorstwo Energetyki Cieplnej, Gniezno	Gniezno	Emission of gases and dusts	Making energy
Wielkopolskie Tartaki "Witar"	Gniezno	Emission of gases and dusts	Timber manufacture
Gniezno, Scanclimber Sp. z o.o.	Gniezno	Emission of gases and dusts	Industrial devices manufacture
NB Polska sp. z o.o.	Gniezno	Emission of gases and dusts	Aggregated emitter

Panasonic Battery Poland S.A.	Gniezno	Emission of gases and dusts	Batteries production
Kierzkowo	Trzemeszno	Emission of odours	Cattle farming
Przedsiębiorstwo Przemysłu Ziemniaczanego	Trzemeszno	Emission of gases without CO_2	Potato manufacture
PAROC Sp. z o.o.	Trzemeszno	Emission of gases and dusts	Materials for insulating houses production
Witowa S.A.	Witkowo	Emission of gases and dusts	Furniture production
Zakład poprawczy, Witkowo	Witkowo	Emission of gases and dusts	-

Source: author's work

16. Results of the survey

In 2014 from October to December author has conducted a survey among the citizens of the Gniezno District. Author of the article spent 4 weekends (Saturdays and Sundays) asking questions about environmental protection in the Gniezno District (terms: 4-5.10, 25-26.10, 15-16.11 and 13-14.12.2014). At the beginning of the survey respondents were identified if or if not they live in the Gniezno District. The survey has included 3 questions about environmental monitoring in the District. Respondents had also to provide their age and sex. In all there was 347 answers collected. Results are given by the figures below (fig. 4-7).

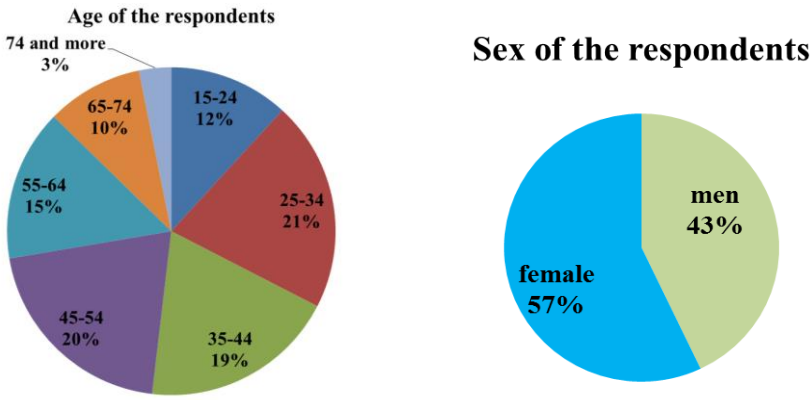

Figure 4. Personal data of respondents who took part in the research (age and sex of the respondents)

Source: Author's work

Every respondent had 3 questions to answer:

1. Do you find natural resources of the Gniezno District as attractive and worthy of protection?
2. Which forms of polish environmental protection can you find in the Gniezno District?
3. Do you think that the environmental protection in the Gniezno District should be increased?

All the questions had only 5 possible answers, but there was also possibility to add some comments to every answer.

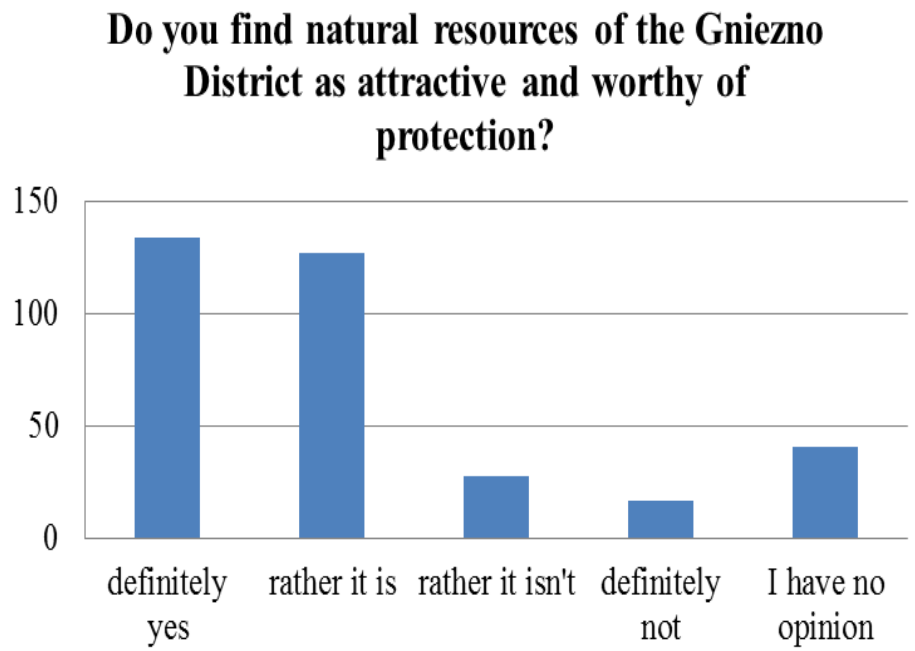

Figure 5. Number of answers for the first question

Source: Author's work

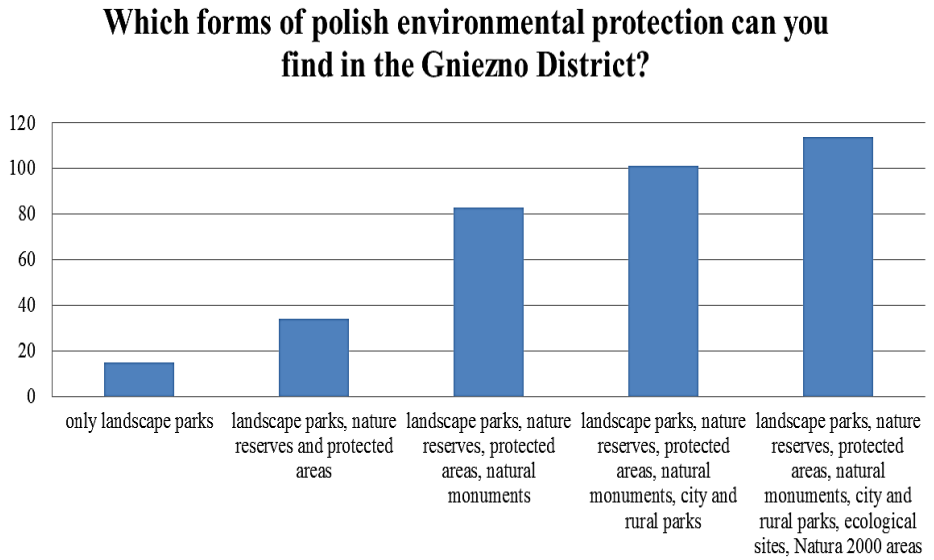

Figure 6. Number of answers for the second question

Source: Author's work

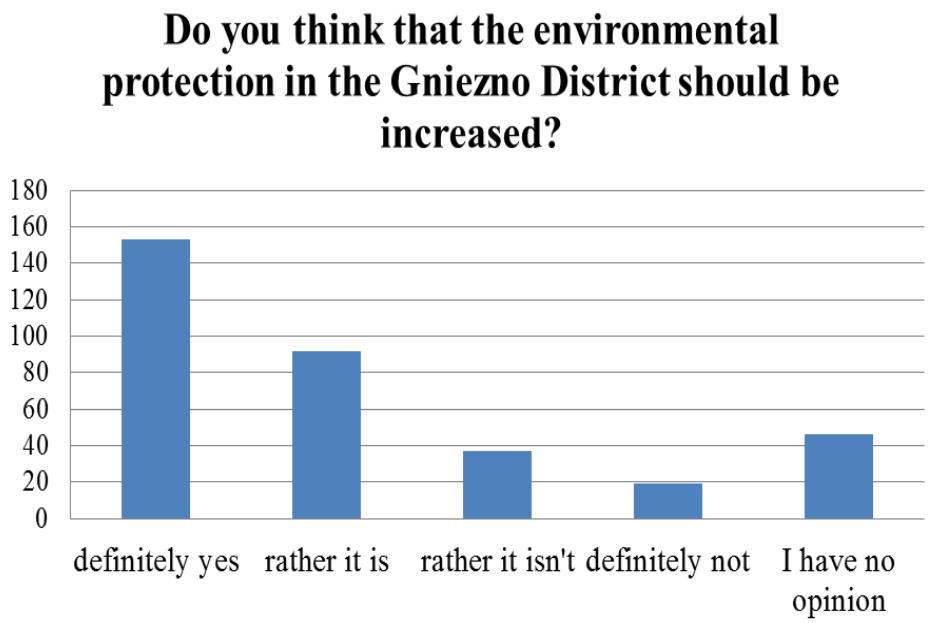

Figure 7. Number of answers for the third question

Source: Author's work

The results of the survey gave the information about citizen's attitude to the environmental protection in their district. Most of the respondents values the natural resources of their district, knows them and wants them to be protected better. There was no connection between age or sex of respondents and their answers. There was one trend observed – if respondents don't know the objects of the question they also can't value it and give opinion about current and future state of it. The positive conclusion is that a large proportion of citizens of the Gniezno District care about their environment and also its protection. Theirs opinion should be a sign for specialists to take into consideration extension of the scope of environmental protection.

17. Results - suggestions for extending the natural environment monitoring network in the Gniezno District

Due to the limited scope of the studies conducted in the Gniezno District and the intensive landscape transformation the area is undergoing, it is recommended to extend the scope of the previous measurements and introduce specialised monitoring of the biosphere, water and ground surface. The extension of monitoring should be implemented for the following categories within National Environmental Monitoring: meteorological monitoring, surface waters monitoring, underground waters monitoring, ground surface monitoring, biosphere monitoring.

17.1. Meteorological monitoring

These measurements include the assessment of the quality and condition of the air as well as measurements strictly associated with meteorology. The legal basis for monitoring air quality within the National Environmental Monitoring is the Environmental Protection Law Act (Art. 85 – 94) together with Implementing Regulations that accommodate the requirements set forth by the Council Directive 96/62/WE of 27 September, 1996 [20] regarding air quality evaluation and management, and the following daughter Directives:

- Council Directive 1999/30/WE of 22 April, 1999 regarding limit values of SO_2, NO_2, NO_x, particle pollution and lead in the atmosphere,
- Directive 2000/69/WE of the European Parliament and of the Council, 16 November, 2000 regarding limit values of benzene and carbon monoxide in the surrounding air,

- Directive 2002/3/WE of the European Parliament and of the Council, 12 February, 2002 regarding ozone content in the air, since 11 June, 2010 replaced by: Directive 2008/50/WE of the European Parliament and of the Council, 21 May, 2008 regarding air quality and the Clean Air for Europe (CAFE) Programme, and Directive 2004/107/WE of the European Parliament and of the Council, 15 December, 2004 regarding arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in the air.

Standardised meteorological measurements should be taken in a properly located and adapted weather station. The requirements for the location of such a station are set by the Institute of Meteorology and Water Management.

In the Gniezno District air condition is monitored in three locations. However, the presence of separate, dispersed pollution emitters may cause local fluctuations in the concentration of sulphuric compounds, nitrates, carbon monoxide, particles and ozone. With this kind of specialised monitoring, the creation of a city-oriented weather station is desirable, since the area of the District remains under strong influence of the city agglomeration and the communication network. Moreover, the probing area of air pollution measurements should be extended to more locations, adequate to the changes taking place in the shape of the terrain (e.g. a station in Wał Wydartowski and near the District's lakes) and to the nature of the area (urban, rural areas, forest).

17.2. Surface waters monitoring

One of the most significant weaknesses of the monitoring network for the Gniezno District is the lack of research regarding surface waters.

Since there are numerous lakes with specific characteristics (narrow, long and deep basins), which are conducive to eutrophication and lower the self-cleaning capacity of the area's waters, the lakes should constitute the most prominent element of the monitoring network in the Gniezno District.

The legal basis for surface waters monitoring system is determined by: Water Law Act of 18 July, 2001, Art. 155a. 2: "...analysis and evaluation of the condition of surface waters, underground waters and protected areas, referred to in Art. 113, paragraph 4, takes place within the National Environmental Monitoring", and:

- Ordinance of the Minister of Environment of 23 December, 2002 regarding the criteria for identifying waters vulnerable to agricultural nitrates contamination,
- Ordinance of the Minister of Environment of 20 August, 2008 regarding the means of classification of water bodies in the surface waters (currently being amended),
- Ordinance of the Minister of Environment of 13 May, 2009 regarding the form and ways of monitoring surface and underground waters (currently being amended).

Lake water purity monitoring should also be organised within the scope of local surface waters monitoring in the Gniezno District. The examination should encompass at least the five largest lakes of the District (Niedzięgiel (637.7 ha), Lednica (348 ha), Kamienieckie (232.5 ha) Ostrowite (276.7 ha), Popielewskie (308.5 ha)). These lakes are characterised by their varying location in relation to different urban and agricultural areas, while, at the same time, they display similar morphological parameters. Therefore, they could be used in a comparative spatial analysis based on the measured factors. While analysing the trophic

state of water bodies, the following need to be taken into account: water temperature, acidity, water chemistry, as well as ecological analyses, e.g. diatom analyses. Selected species of floating and reed bed plants may also be a good trophy indicator. Measurements should be made at least quarterly (it needs to be remembered that in lake research spring and autumn mixings are taken into account).

Local monitoring in the studied area should include a water flow and water level measurement point for the Wełna River, which is one of the tributaries of the Warta River. For comparison and diagnostics a basic analysis of the waters of this river should be conducted at least quarterly. It would include: water temperature and acidity as well as hydro-chemical analysis.

17.3. Underground waters monitoring

The legal basis for underground waters monitoring system is determined by:

- Water Law Act of 18 July, 2001, Art. 155a.2: "...analysis and evaluation of the condition of surface waters, underground waters and protected areas, referred to in Art. 113, paragraph 4, takes place within the National Environmental Monitoring",
- Ordinance of the Minister of Environment of 23 July, 2008 Regarding the criteria and means of evaluating the condition of underground waters,
- Ordinance of the Minister of Environment of 13 May, 2009 regarding the form and ways of monitoring surface and underground waters,

- Ordinance of the Minister of Environment of 23 December, 2002 regarding the criteria for determining waters vulnerable to agricultural nitrates contamination.

The National Geological Institute and the Chief Environmental Protection Inspectorate evaluated the condition of underground waters in 2010 as good/poor. In association with this qualitative evaluation, supplementary water chemistry analysis should be conducted for the underground waters of the region. Quantitative analysis lies within the responsibilities of the Polish Hydrogeological Survey, which assessed the quantity of the District's waters as low in 2010. Due to the unsatisfactory results of the assessment, in order to amend the current state of affairs, the following measures should be taken:

- identification of the pollution spots for underground waters (surface, spot, primary and secondary pollution),
- evaluation of their impact on underground waters,
- determining the speed of pollution spread based on hydro-geological conditions, characteristics of the medium, type of pollution etc.,
- evaluation of the threat level for existing underground water intakes,
- evaluation of the threat level for aquifers valuable from the perspective of water management,
- determining the extent of current changes in underground waters.

17.4. Ground surface monitoring

In the Gniezno District, ground surface monitoring is possible within the following scope: erosional-depositional processes monitoring in rivers and lakes, soil erosion monitoring, aeolian processes monitoring, landslide monitoring and extreme geological events monitoring.

In the case of soil erosion monitoring, it is recommended to undertake field and laboratory studies regarding soil chemistry, its structure and cohesion. When it comes to the remaining types of surface monitoring, test fields should be created in selected areas. These can be areas representative of different geoecosystem types, e.g. agricultural lands and areas with natural vegetation.

17.5. Biosphere monitoring

The biosphere monitoring subsystem includes: species and habitat monitoring, bird monitoring, and forest monitoring. Within the area of the Gniezno District there are valuable areas under partial protection (landscape parks, Nature 2000 areas and others), where biosphere monitoring should be conducted. For the Nature 2000 areas, species and habitat protection is managed by the Regional Directors for Environmental Protection. The local authorities and other units of public administration extend their protection over landscape parks and the remaining protected areas.

18. Conclusions

Based on the analysis of the state of the natural environment in the Gniezno District and the current state of its monitoring, the following conclusions have been made:

1. The natural environment of the Gniezno District is undergoing constant transformations and remains under increasing human influence.
2. Specific components of the environment in the area undergo diverse transformations and have a varying degree of vulnerability to external factors.

3. In the area of the District, the spatial scope of monitoring is too small. Therefore, local changes in the environment and their variability across the area are unknown.
4. Current monitoring concerns exclusively air quality and noise level. Due to this situation, developing the existing monitoring network is recommended. New facilities should probe surface waters, underground waters, and the surface of the ground.
5. Air purity monitoring, currently conducted in the area, should be extended by meteorological measurements.
6. Development of the National Environmental Monitoring network in specific districts would enable more specific data collection and allow the identification of local chemical compound fluctuations in the atmosphere, hydrosphere, pedosphere and biosphere.
7. The natural environment monitoring of the Gniezno District should also take into account the historical value of the area of Gniezno and its significance for future generations.

19. Summary

In a longer perspective, the possibilities for the development of the monitoring network or the creation of localised monitoring facilities should be considered in the area. This will enable the collection of data on the local variation of specific components of the landscape. The protection of inanimate nature, secondary in most protection programmes, is a task of special importance. Abiotic components of the environment constitute the basis for the functioning of life in a given area. Therefore, the protection of waters, ground surface and atmosphere should constitute one of the

aspects of living in harmony with nature, both for the people associated with National Environmental Monitoring as well as for any other citizen.

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Characteristics of technological purification of underground water for Bialystok and assessment of WTP in Jurowce efficiency

Key words: u*nderground water, confined groundwater, water treatment plant*

Summary: The article is a supplement to the information on the water captured for the needs of Bialystok inhabitants. They concerned the composition of surface waters and efficiency of WTP Pietrasze - Wasilków, which is an alternative source of water for the city. In this article, the groundwater and methods and processes used at the water treatment plant in Jurowce, was characterized. It also presents stages of WTP modernization. The analysis involved samples of underground raw and treated water collected in 2015. In the months from January to December, investigated physicochemical and microbiological parameters of water were investigated. The frequency of testing was 10 times a month. The aim of the study was to assess the quality of underground water captured in Jurowce and treated water.

1. Introduction

One of the side effects of the civilization progress is the worsening state of environment. Among other things, it manifests itself as adverse changes in the chemical composition of natural waters (waterbody). The underground waters are characterized by more favorable physical, chemical and bacteriological status than surface water. Groundwater have higher transparency, no suspensions, constant temperature and generally low content of organic matter and bacteria. By contrast, they contain the elevated amount of dissolved minerals[16]. But in recent years, the

increased level of anthropogenic pollution can be found even in groundwaters [13]. Water is the most precious natural resource determining the state of natural environment and human life and health. There is less and less amount of clean water, that is essential to life, while its importance is increasing.

Groundwater, as the largest body of freshwater in the European Union, are the main source of drinking water supply in many regions [2]. Formed by a variety of geological processes, water is stored under the Earth's surface at different depths. The total volume of groundwater is 60 000 thousand km³, which is around 4.12‰ of the total capacity of Earth's hydrosphere resources [2]. Zone of groundwater saturation is called the saturation zone and is located below the zone of soil air and other gases saturation, i.e. aeration zone. The saturation zone can contain water, but only as suspended or bounded water: hygroscopic, adhesive, capillary water. The parameters of groundwater differ significantly from these of surface water. They include: relatively slow flow-rate, longer retention times and very slow elimination of pollution associated among other with their physicochemical and biological properties [2]. The underground water are characterized by a rather constant physicochemical composition that is shaped by hydro-geochemical processes; they are also affected by physical and biological processes (especially biochemical) such as oxidation and reduction, dissolution (leaching) and precipitation, hydration and hydrolysis, weathering, sorption, desorption, ion exchange and membrane processes, migration (dispersion) [3,4].

Groundwater is a natural resource, which should be protected from deterioration and pollution, both chemical and microbiological. The danger degree of the main groundwater-carrying layer is derived from the effect

of three groups of factors: its resistance to pollution, the presence of pollution sources, and the land availability. One of the important factors threatening the groundwater, is contamination along the transportation routes, especially those running through areas where the aquifer is uncovered.

The aim of the article was to analyze the composition of groundwater captured for the needs of Bialystok residents and the evaluation of the treated water quality.

2. Characterization of environmental and hydrogeological conditions

Bialystok, the capital city of Podlasie region, is the largest economic, scientific and cultural center, as well as the main railway and road junction in the north-east part of the country. In December 2015, the city had a population of 295 624 inhabitants [1]. The Bialystok Upland is wavy and wavy-hilly, varied with shafts of terminal moraines and kames, the old-glacial plateau, cut by river valleys. In the northern stretch of the hill moraine of stadials of middle and upper glaciation (the Mid-Poland glaciation), made up of loam sand and gravel formations. The relief is very diverse. The altitudes reach 50 m.a.s.l. and undulating hilly-moraine hills reach 200 m.a.s.l. Białystok region, in hydrographic terms, is located in the right bank of Narew river catchment. Supraśl river, with the right-bank tributary Czarna river and left-bank tributaries Biała and Pilnica rivers, is the natural draining axis. The south-western part of the area is dewatered by Horodnianka river [12].

Hydrogeological conditions in the vicinity of Bialystok (Figure 1) are significantly influenced by water-bearing formations of Quaternary layer (Pleistocene level).

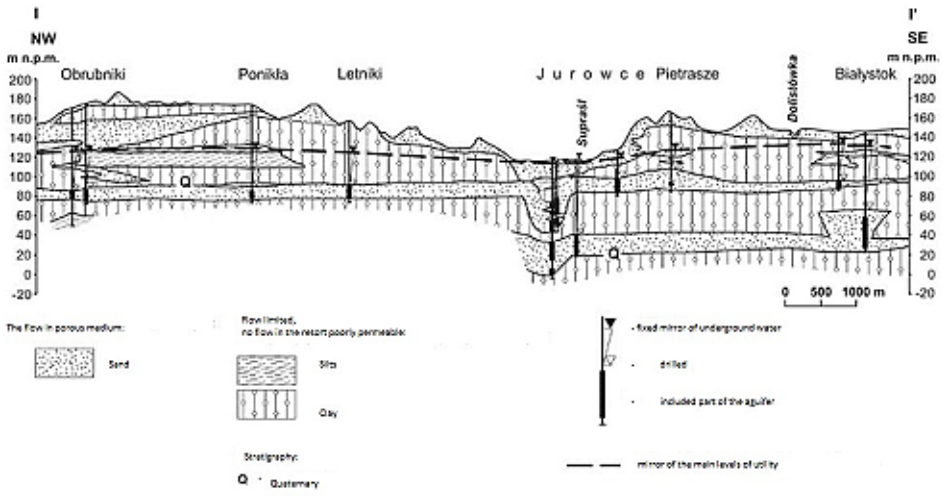

Figure 1. Hydrogeological cross-section I – I' across Białystok region

Source: [12]

2.1. Groundwater intake in Jurowce

The groundwater intake in Jurowce is located on the right bank of Supraśl river valley, on both sides of the national road No. 19 Białystok-Augustow. The intake covers an area of about 58 hectares, with 27 wells, of which 19-20 wells works continuousl. All wells of the groundwater intake in Jurowce capture the aquifer of Quaternary level. Technological line for groundwater treatment has a capacity of 42 240 m^3/day. The diagram of groundwater intake in Jurowce is shown in Figure 2.

The most important modernization stages of WTP in Jurowce included:

- Rapid filters–exchange of the old drainage into TRITON system and anthracite-sand beds (2001),
- Replacement of water aeration with ozonizing (2005),
- Building for preliminary ozonizing in WTP Jurowce (March 2004 - September 2005).

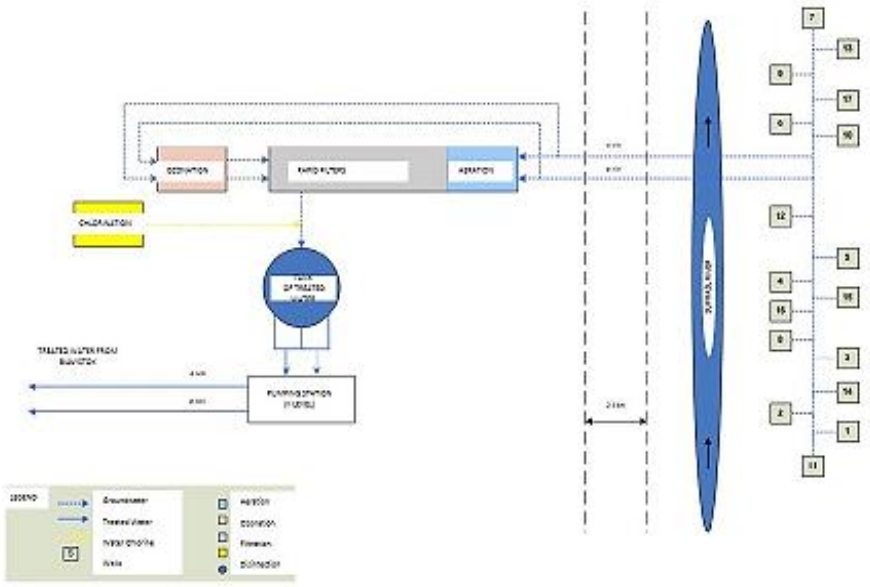

Figure 2. Technological diagram of intake and treatment of confined groundwater at WTP Jurowce

Source: [17]

As reported by Królikowski and Walery (1997) [5], water resources of that estuary in B category were approved in 1966 for the amount of 34344 m^3/d (1431 m^3/h). Their updating in 1995 showed a total exploitation resource at the level of 1760 m^3/h, including 1400m^3/h from alluvial layer at depression 0.8-3.7m, and deeper Pleistocene level 360m^3/h at depression 1.9-2.5m. The groundwater intake in Jurowce, also localized in Supraśl river valley, consists of 17 well sets. Each set is composed of a single basic well and a single emergency well. The depths of individual wells are from 16 to 122 m. Ten well sets exploit the alluvial layer and other wells capture water from the confined layers. Locally, the subsurface and confined layers are connected. The operating performance

of individual wells is between 50 and 250 m^3/h. As a result of intensive exploitation of groundwater in the intake area, regional depression craters arose. The largest crater can be found in the first utility deep aquifer in the area of Jurowce intake. Depth of the crater in the center is about 5m, and its area is estimated for 5.2 km^2. In the second usable confined aquifer, only one depression crater was diagnosed in the area of Jurowce intake. It has a depth of 5 m in the center, and the area of its range is estimated for 8-9 km^2 [8]. Groundwater of all aquifers occurring in the area of intake supply for Bialystok belongs to the straight bi-ionic water of HCO_3–Ca type. Samples of no layer revealed an excess of heavy metals [9, 10]. The subsurface aquifer water is poorly mineralized (most often, dry residue amounts from 280 to 370 mg/dm^3). Chlorides are present usually at concentrations from 7 to 110 mg/dm^3, while sulfates from 13 to 127 mg/dm^3. Ammonia content is low not exceeding 0.10 mgN/dm^3, nitrates locally reach 15 mgN/dm^3. The iron compounds occur at small amounts from 0.0 to 0.4 mg/dm^3, while manganese from 0.0 to 0,08 mg/dm^3. General hardness changes from 1.9 to 9,9 mval/dm^3, and pH value is from 7 to 7.6. These are fairly good-quality waters, but due to the lack of insulation, they are exposed to anthropogenic pollutants [9, 10].Quality of the first utility confined aquifer varies spatially in different areas. In the upland areas, the water has a low mineral content, and is moderately hard (2.3–7.2mval /dm^3), with slightly alkaline reaction (from 7.2 to 7.8). Its color and turbidity is considerably elevated. Locally, increase in ammonia can be observed up to 1 mgN/dm^3 (ammonia ions have mineral origin). Nitrates and nitrites occur in trace quantities. Chlorides and sulfates are usually recorded at low concentrations and only near Białystok, their slightly increased contents are found (Madejski, Madejska, 1998a, b)

[9,10]. There are good-quality waters requiring only a simple treatment due to the high content of iron and manganese,in the northern part of the moraine plateau (north of the Supraśl river valley) and south of the Supraśl river valley in the north-east of Bialystok, as well as in the area of Choroszcz. Water from the remaining part of the upland, mainly due to the share of iron (>2.0 mg/dm^3) and/or manganese compounds (>0.1 mg/dm^3. Analysis of results from studies performed by Małecka [11], Macioszczyk [6,7], Madejskiet al. [8] indicated a secondary increase in iron and manganese compounds concentrations resulting fromhydro-geochemical changes near intensively exploited sewerage system intakes due to depressing the water surface level and alterations in redox conditions at the border of aeration and saturation zones; increase in the relative share of sulfates and chlorides at the expense of bicarbonates as well as potassium and sodium share increase at the expense of calcium, and in addition the increase of nitrogen compounds concentrations (nitrates and nitrites), which causedthe worsening the water quality decrease from good yet unstable, to moderate, while requiring a simple treatment near the area of intake points. Water of Supraśl river valley is poorly mineralized (dry residues< 500 mg/dm^3), usually moderately hard with weakly alkaline reaction (7.6 to 7,8). Iron content oscillates from 0.2 to 6.0 mg/dm^3, and that of manganese from 0.03 to 0,5 mg/dm^3. Nitrogen compounds do not exceed the standards set for drinking water. Water quality of the second confined usable aquifer is not well recognized. Due to the small number of holes documenting this layer, a description of its physicochemical parameters is not very accurate. Tested samples are characterized by an elevated content of iron from 0.8 to > 3 mg/dm^3, high mineral-origin ammonia content from about 0.5 to > 2 mgN/dm^3, and increase color.

Chlorides, sulfates and other nitrogen compounds are very low. Manganese occurs at amounts from 0.08 to 0.1 mg/dm^3, and reaction ranges from 7.1 to 7.5. The waters are well insulated and they are subject to anthropopressure to a small extent [6,8,11].

3. Methods

The study was conducted in 2015, from January to December. Each month, 10 measuring cycles were made. Results of the study were shared by the Laboratory of Water Assessment in Białystok Waterworks. Samples of underground, raw and treated water were subject to the following determinations in accordance with the methodology specified below [14, 15]:

Ammonia (0.10 mg NH_4^+/dm^3÷10.0 mg/dm^3) – spectrophotometry according to PN-ISO 7150-1:2002,

Nitrates(V)(0.10 mgNO_3^-/dm^3÷200 mgNO_3^-/dm^3) - spectrophotometry according toPN-82/C-04576/08,

Nitrates (III) (0.03 mgNO_2^-/dm^3÷2 mgNO_2^-/dm^3) - spectrophotometry according toPN-EN26777:1999,

Color (5 mg Pt/ dm^3÷350 mg Pt/dm^3) - spectrophotometry according to PN-EN ISO 7887: 2012 Method C,

Chlorides(5.0 mg/ dm^3 ÷ 400 mg/dm^3) - titration according to PN-ISO 9297: 1994,

Permanganate index(0.5 mg/ dm^3÷80 mg/ dm^3) - titration according to PN-EN ISO 8467: 2001,

Manganese (20 μg/ dm^3 ÷4000 μg/ dm^3) - spectrophotometry according to PN-92/C-04590/03 for iron content< 500 μg/L,

Manganese (10 μg/ dm^3 ÷ 600 μg/ dm^3) - GFAAS according to PN-EN ISO 15586: 2005,

Turbidity (0.20 NTU ÷ 1000 NTU) - nephelometry according to PN-EN ISO 7027: 2003 rozdz. 6,

Reaction(4 pH ÷ 10 pH) - electrometry according to PN-EN ISO 10523: 2012 (E),

Specific conductivity (100 μS/cm ÷ 3000 μS/cm) - conductometry according to PN-EN 27888: 1999,

Iron (20 μg/ dm^3 ÷ 25000 μg/ dm^3) - spectrophotometry according to PN-ISO 6332: 2001,

Iron (20 μg/ dm^3 ÷ 250 μg/ dm^3) - GFAAS according to PN-EN ISO 15586: 2005,

Iron (100 μg/ dm^3 ÷ 5000 μg/ dm^3) - FAAS- PRB-09 ed. 1 from 25.09.2014,

Dissolved oxygen (2.0 mg/ dm^3 ÷ 20.0 mg/ dm^3) - electrometry according to PN-EN 25814: 1999,

Coli bacteria count (NPL) in 100 cm^3 water (0 ÷ 2000) bacteria/100 cm^3- enzymatic (Colilert) - PRB-14 ed. 2 from 06.10.2010,

Coli bacteria count in 100 cm^3 water (0 ÷ 100) CFU/100 cm^3- membrane filtration agar TTC withTergitolaccording to PN-EN ISO 9308-1:2004+Ap1:2005+AC:2009,

Escherichia coli count (NPL) in 100 cm^3 water (0 ÷ 2000) bacteria/100 cm^3- enzymatic (Colilert)- PRB-14 ed. 2 from 06.10.201,

Escherichia coli count in 100 cm^3 water (0 ÷ 100) CFU/100 cm^3- membrane filtration agar TTC withTergitolaccording to PN-EN ISO 9308-1:2004+Ap1:2005+AC:2009

***Enterococcus faecalis* count (NPL)** w 100 cm^3 water (0 ÷ 2000) bacteria/100 cm^3- enzymatic (Enterolert)- PRB-14 ed. 2 from 06.10.2010.

4. Results and Discussion

Chemical composition and quality of raw groundwater determined in test cycles in 2015 was shown in Table 1. Table 2 presents qualitative composition of treated water subject to analysis the same time.

Table 1. Parameters of raw groundwater

Parameter	Unit	2015											
		Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Temperature	ºC	9,0	9,0	9,0	9,0	9,0	9,0	9,3	9,0	9,0	9,0	9,0	9,0
Color	mgPt/dm^3	25,1	25,7	23,2	26,0	23,2	23,1	24,8	27,5	23,2	23,1	24,1	24,2
Turbidity	NTU	1,0	0,9	1,8	1,1	1,7	1,1	1,4	1,3	1,4	1,9	1,7	1,5
Reaction	pH	7,5	7,5	7,5	7,5	7,5	7,5	7,6	7,6	7,6	7,6	7,6	7,6
Temp. of acidity measurement	ºC	20,0	20,1	20,1	20,1	20,2	19,0	18,9	19,3	19,2	20,1	20,1	19,9
Specific conductivity	µS/cm	478,0	490,0	489,0	490,0	480,0	474,0	480,0	452,0	470,0	475,0	480,0	490,0
Temp.of specific conductivity measurement	ºC	20,0	20,0	18,5	21,9	17,6	19,2	19,6	18,5	20,3	22,1	21,5	16,2
Ammonia	mgNH_4^+/dm^3	1,1	1,3	1,5	1,4	1,3	0,7	1,5	1,6	1,5	1,6	1,3	1,6
Nitrates(V)	mgNO_3^-/dm^3	0,5	0,5	0,6	0,4	0,4	0,5	0,2	0,3	0,3	0,2	0,3	0,7
Nitrates (III)	mgNO_2^-/dm^3	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03
Manganese	µgMn/dm^3	108,0	101,0	104,0	109,0	96,0	102,0	94,0	94,0	93,0	97,0	98,0	99,0
Total iron	µgFe/dm^3	746,0	748,0	911,0	798,0	1097,0	944,0	1034,0	986,0	1001,0	1177,0	1110,0	1054,0
Permanganates	mgO_2/dm^3	4,1	3,9	4,2	4,0	3,6	3,5	4,0	3,5	3,9	3,8	3,7	4,1
Chlorides	mg/dm^3	5,5	5,8	5,7	5,8	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0
Sulfates	mg/dm^3	6,6	8,0	7,5	7,1	5,9	5,8	8,6	6,4	6,6	<5,0	6,1	6,6
Coli bacteria	CFU/100 cm^3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Escherichia coli	NPL/100 cm^3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Enterococci	NPL/100 cm^3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Dissolved oxygen	mgO_2/dm^3	5,3	5,0	2,8	4,9	0,6	5,9	1,7	1,9	5,6	0,8	9,6	6,1

Source: Białystok Waterworks, Ltd.

Table 2. Parameters of treated water

Parameter	Unit	2015											
		Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Temperature	ºC	8,3	8,6	8,7	8,9	8,8	9,0	9,3	9,1	9,5	9,2	9,0	8,9
Color	$mgPt/dm^3$	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0	<5,0
Turbidity	NTU	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2	<0,2
Reaction	pH	7,4	7,4	7,4	7,4	7,4	7,4	7,4	7,4	7,4	7,4	7,5	7,4
Temp. of acidity measurement	ºC	20,1	20,2	20,1	20,0	20,2	19,2	19,4	20,6	19,5	20,0	20,2	20,2
Specific conductivity	µS/cm	486,0	488,0	485,0	481,0	482,0	470,0	467,0	465,0	473,0	477,0	473,0	478,0
Temp.of specific conductivity measurement	ºC	20,4	20,8	20,8	20,0	20,5	18,8	19,1	19,2	18,9	20,3	20,3	20,1
Ammonia	$mgNH_{4+}/dm^3$	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1
Nitrates (V)	$mgNO_{3-}/dm^3$	4,3	4,4	4,3	5,2	4,8	4,8	4,6	4,2	4,6	4,4	4,6	4,8
Nitrates (III)	$mgNO_{2-}/dm^3$	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03	<0,03
Manganese	$\mu gMn/dm^3$	<10,0	<10,0	<10,0	<10,0	<10,0	<10,0	<10,0	<10,0	<10,0	<10,0	<10,0	<10,0
Total iron	$\mu gFe/dm^3$	25,0	24,0	26,2	25,0	25,0	23,0	23,0	23,0	25,0	26,0	29,0	35,0
Permanganates	mgO_2/dm^3	2,6	2,7	2,3	2,5	2,4	2,3	2,1	2,3	2,5	2,5	2,4	2,7
Chlorides	mg/dm^3	8,4	7,8	7,1	7,8	6,8	7,7	6,5	7,8	7,3	7,0	5,9	5,7
Sulfates	mg/dm^3	7,2	8,5	9,0	8,6	7,4	8,0	7,0	7,5	7,6	6,3	6,2	6,0
Coli bacteria	CFU/100 cm^3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Escherichia coli	NPL/100 cm^3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Enterococci	NPL/100 cm^3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Source: Białystok Waterworks, Ltd.

Based on the study results, it was found that the pH value of raw underground water in 2015 was 7.5 from January to June and 7.6 in the period from August to December. Color of the groundwater captured for the needs of Bialystok citizens during analyzed period was similar and varied within the range from 23.1 (June and October) to27.5mgPt/dm^3 (August). Considering the analyzed year of study, the highest turbidity of raw water (1.9 NTU) was recorded in October, while the lowest (0.9 NTU) in February. Specific conductivity of raw groundwater was uniform amounting from 452 (August) to 490 μS/cm (February, April, and December 2015). The highest concentration of ammonia in raw water 1.6 mgNH_4^+/dm^3 was observed in August, October, and December. In June, groundwater contained the lowest ammonia concentration of 0.7 mgNH_4^+/dm^3. Level of nitrates(V) in raw water was from0.2to 0.7 mgNO_3^-/dm^3. The highest one was found in December, whereas the lowest in July and October2015 (Table 1). Concentration of nitrates (III) in groundwater captured in Jurowce intake in 2015 did not exceed 0.03 mgNO_2^-/dm^3. The lowest content of total iron (746 μgFe/dm^3) was recorded in January, while the lowest concentration of manganese (93 μgMn/dm^3) in water analyzed in September. The highest iron concentration (1177 μgFe/dm^3) was found in October and that of manganese (109 μgMn/dm^3) in April. The permanganate index of raw groundwater varied from 3.5 mgO_2/dm^3 in June and August to 4.2 mgO_2/dm^3 in March (Table 1). Chloride concentration was not greater than 5 mg/$dm^3$from May till December 2015, and the highest levels(5.9 mg/dm^3) were determined in water collected in February. The lowest concentration of sulfates (below 5 mg/dm^3) was found in October, while the highest 8.6 mg/dm^3in July. The lowest level of dissolved oxygen (0.6 mgO_2/dm^3) in groundwater captured in Jurowce was found in May, whilst the highest one9.6 mgO_2/dm^3 in November. Neither *Coli* group

bacteria, nor *Escherichia coli* and *Enterococci* were not detected in captured water (Table 1).

5. Conclusions

Based on the monitoring of chemical status (quality) of groundwater captured for the needs of Białystok inhabitants in Jurowce, conducted over 2015, following conclusions can be drawn:

1. There is no need to take protective measures aimed at improving the status of these waters.
2. Concentrations of substances in captured waters and their limit values set out in the Regulation of the Minister of Health from 13 November 2015, meet the microbiological requirements. Most of the parameters (except iron) also meet the organoleptic and physicochemical requirements.
3. The underground water treatment system in the WTP Jurowce is highly efficient.
4. Water supplied to consumers meets the requirements of the law, and values of the parameters in treated water are lower than the limits.
5. Białystok region has good hydrogeological conditions and good water quality and can be used as the location of emergency source of water supply under conditions of extreme events.

The publication was created as a part of the statutory work S/WBiIŚ/3/2014 and own work MB/WBiIŚ/13/2015 at The Department of Technology in Civil and Environmental Engineering, Technical University of Bialystok, as well as by courtesy and help of Białystok Waterworks Ltd.

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