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ELEMENTS OF ENVIRONMENTAL EDUCATION IN THE NEW POLISH CURRICULUM FOR TEACHING CHEMISTRY AND SELECTED CHEMISTRY TEXTBOOKS AT ISCED 2 AND ISCED 3 LEVEL

ELEMENTY EDUKACJI PROŚRODOWISKOWEJ W NOWEJ PODSTAWIE PROGRAMOWEJ PRZEDMIOTU CHEMIA ORAZ W WYBRANYCH PODRĘCZNIKACH DO NAUCZANIA CHEMII DLA III I IV ETAPU KSZTAŁCENIA

Abstract: In 2009 the Ministry of National Education introduced a new core curriculum for general education in Poland which completely transformed environmental education at ISCED 2 (Polish: *gimnazjum*, junior high school) and ISCED 3 (post-*gimnazjum*, senior high schools of different types) stages. Considering the immense impact of chemical substances on the state of global nature, the curriculum for chemistry plays a pivotal role in the development of environmental knowledge and pro-environmental attitudes among students in Polish schools. There is no doubts that not only are chemistry textbooks the basic source of scientific knowledge for students, but they also inspire teachers during class preparation. The educational reform created a need for updating chemistry textbooks according to new core curriculum. The aim of this work was to investigate the coherence between elements of environmental education required by core curriculum and the depiction of these issues proposed in textbooks. Textbooks of major Polish educational publishers for junior and senior secondary schools at basic level were analyzed. The results of this study show that all examined textbooks are coherent with environmental issues included in the program fundamentals, but they also give additional pieces of information when needed, even when such content is not precisely defined in the core curriculum (eg organic chemical waste problems). The comparison of selected textbooks provided information on the present state of education reform implementation and on what could be improved or clarified in the new core curriculum regarding environmental problems.

Keywords: environmental education, pro-environmental attitude, new core curriculum, chemistry textbooks

Introduction

The Science Section of the Educational Research Institute participates in a project called *Teaching quality and school effectiveness - building tools for research - Passionate about Education* which main goals are: providing teachers with educational tools and novel solutions to evaluate students' thinking skills, interdisciplinary research in Poland and other countries, reports on the state of education in Poland and reports on the implementation of New Science Core Curriculum [1] into teaching programs and school textbooks.

Environmental and ecological content is present in the new core curriculum of all traditional subjects but biology, geography and *natural science (przyroda)* are considered to be the most important in the scope of environmental education in Polish schools [2], and the role of chemistry in the environmental education seems to be overlooked. Since chemical industry and chemical substances used in everyday life are major sources of pollutants of air, water and soil, and they contribute immensely to such harmful processes

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as the formation of the ozone hole, acid rains and greenhouse effect, chemistry teaching should be perceived as crucial in the development of environmental knowledge and pro-environmental attitudes among students. Teaching chemistry bases on the core curriculum, textbooks approved by The Ministry of Education and teaching programs approved by school headmasters (in consultation with teachers and school board). The amount of time which can be spent on the realization of the program is restricted, therefore teachers do not have much time for discussing issues in details. Students who wish to broaden or consolidate their scientific knowledge have to reach for chemistry textbooks, thus the importance of this source of learning cannot be omitted. The new science curriculum forced publishers to update chemistry textbooks. Noteworthy is that new textbooks can be also extremely helpful for teachers who need to prepare their classes in accordance with the new core curriculum.

The main aim of this paper was to investigate the environmental issues included in the new core curriculum for subject chemistry and their implementation in various chemistry textbooks for junior high school (ISCED 2) and 1st grade of senior high school level (ISCED 3).

Environmental education in Polish schools

In 1987 the Brundtland Report of the World Commission on Environment and Development defined the term “sustainable development” as a process whose goal is to satisfy the growth aspirations of the present generation in such a way as to enable the future generations to also satisfy their aspirations [3]. The authors of this report specified three areas important for planning an effective strategy of achieving sustainable development: i) environmental protection and rational exploitation of natural resources (*eg* minimizing environmental pollution, protection of endangered plant and animal species, promotion of renewable energy sources); ii) economic growth and fair distribution of its benefits (*eg* changing ineffective models of production and consumption); iii) social growth (*eg* fighting poverty, widening access to education and healthcare). These goals cannot be achieved without providing extensive environmental education [4, 5] and pro-environmental attitude [6].

The previous educational system paid less attention to ecological issues, and as a consequence Polish society had relatively low awareness of environmental problems and sustainable development [2]. In recent years, several government documents appeared which changed the former policy into a more pro-environmental one. In 1999 educational system in Poland underwent a major reform, which led to transformation of the structure of school system and introduction of significant changes in the core curriculum. The Ministry of Education has defined educational goals, teaching content, tasks for schools and skills to achieve by students for each level of environmental education in the formal system. In practice, environmental education was limited to providing knowledge about environmental protection [7]. In 2009 the Ministry of Education introduced a new core curriculum [1] for general education in Poland, which was a natural step in shaping environmental education at all levels of teaching. Its main aim was to give more specific goals of education and teaching content, exclude information in excess and focus on developing skills important for scientific reasoning. Environmental issues are incorporated within individual program

of each science subject, and in the form of separate interdisciplinary subject called *natural science*. *Natural science* is particularly important for teaching environmental issues at primary schools. The environmental content present in the core curriculum of individual science subjects (*ie* biology, geography, chemistry and physics) are complementary to each other. The main educational goals of environmental education are: raising the awareness about the threats to the natural environment and actions which can be done to protect the natural environment, and arousing of students' respect for nature. The school's task involves the shaping of students' pro-environmental motivation and attitudes [1]. Teaching chemistry in the context of real-world problems and implementing it in environmental and social issues can help students to close the gap between school science, applications of science and technology, and their critical evaluation [8].

Materials and methods

The position and estimated market share of textbooks' publishers were basic criteria for selection of analyzed textbooks. Many publishing companies in the education sector refuses to disclose any sales figures regarding school textbooks. It has been only established, that at junior high school level the biggest publishing houses have a strong position, *ie* Wydawnictwa Szkolne i Pedagogiczne (WSiP), Nowa Era, and Oficyna Edukacyjna Krzysztof Pazdro (Pazdro). At senior high school level, decisive leaders are Wydawnictwo Pedagogiczne OPERON and WSiP [9].

Table 1

The list of selected textbooks for teaching chemistry at ISCED 2 and ISCED 3 levels

No.	Code	Textbook title	Authors	Publisher
ISCED 2 level				
1.	J01	Ciekawa chemia. Podręcznik gimnazjalisty. Część 1-3	H. Gulińska, J. Smolińska	WSiP
2.	J02	Chemia w gimnazjum. Podręcznik	Z. Kluz, K. Łopata, E. Odrowąż, M. Poźniczek	WSiP
3.	J03	Chemia 1-3. Podręcznik dla gimnazjum. Część 1-3	M. Szczepaniak, J. Waszczuk	OPERON
4.	J04	Chemia Nowej Ery. Część 1-3. Podręcznik dla gimnazjum	J. Kulawik, T. Kulawik, M. Litwin	Nowa Era
ISCED 3 level				
5.	S01	Chemia. Po prostu. Podręcznik dla szkół ponadgimnazjalnych. Zakres podstawowy	H. Gulińska, K. Kuśmierczyk	WSiP
6.	S02	Chemia. Zakres podstawowy. Podręcznik dla szkół ponadgimnazjalnych	J. Meszko	OPERON
7.	S03	To jest chemia. Podręcznik dla szkół ponadgimnazjalnych. Zakres podstawowy	R. Hass, A. Mrzigod, J. Mrzigod	Nowa Era
8.	S04	Chemia na co dzień. Podręcznik do szkół ponadgimnazjalnych. Zakres podstawowy	K. Pazdro, R. Szmigielski	Pazdro

Currently, there are eight series of chemistry textbooks for ISCED 2 level and seven textbooks for chemistry course at ISCED 3 basic level available at the educational

publishing market. All of them has been approved by the Ministry of National Education as coherent with the new core curriculum for teaching chemistry and admitted for teaching in schools [10]. For the purpose of this study, we selected four textbooks of major Polish educational publishers intended for ISCED 2 stage, and these textbooks were coded with the letter J associated with numbers from 1 to 4. For ISCED 3 stage at basic level we have also chosen four chemistry textbooks, and selected textbooks were coded with the letter S and associated with numbers from 5 to 8. In Table 1 we have listed all the books selected for the purpose of this study.

The core curriculum for chemistry at ISCED 2 and ISCED 3 stages contains several modules with environmental issues. In our study, we decided to investigate curricular teaching content present in selected textbooks with some important extracurricular terms associated with depicted environmental issues (eg greenhouse effect, hazard connected with hydrocarbons usage, recycling plastic waste etc.). We classified textbooks' content on the basis of curricular items' presence and its description, number of illustrations per topic and number of questions or tasks for practicing skills in comprehension section. The notes for curricular content representation were as follows: C - this item is present and its description is extensive; A - this item is present and its description is concise; P - this element is only slightly mentioned; and NP - examined element is not present in the textbook. We gave number of illustrations (pictures, schemes, figures or tables) appearing in analyzed topic, since a lot of information was presented in this form. We could not evaluate extracurricular topics in the same way as obligatory items, thus we simply marked their presence by "+" or absence by "-", and any kind of presence was considered to be advantageous.

Results and discussion

Environmental issues in the new core curriculum at ISCED 2 level

A junior high school (*gimnazjum*) appeared in the Polish educational system in 1999 as a compulsory three-year school intended for educating children from 13 to 16 years old. Study in this type of school ends with an external examination prepared and conducted by Central Examination Commission (*Centralna Komisja Egzaminacyjna*, CKE). The implementation of environmental education in the teaching process at ISCED 2 level relies on the content incorporated in the syllabuses of all science subjects, mainly biology and geography (*natural science* as a separate subject is absent at ISCED 2) but the new core curriculum for teaching chemistry also includes some important topics of this matter.

In the section of general aims of education (learning outcomes), the importance of environmental issues as part of chemistry teaching is indicated by the following goal: *II - Reasoning and application of acquired knowledge to solve problems. Student is aware of the properties connection of various substances with their usage, and their impact on the natural environment* [1]. In the teaching content segment of the curriculum the issues such as ozone depletion, rational water management, air pollution and acid rains are mentioned. Students should acquire the abilities and habits of acting in accordance with the principles of caring for personal health and the protection of the environment. The modules of core curriculum with teaching content connected with environmental problems were listed in Table 2.

Table 2

The environmental content required by the core curriculum for chemistry at ISCED 2 level [1]

Curriculum module	Teaching content	
	No.	Detailed requirements
MODULE 4. Air and other gases	5	Student describes the formation of the ozone hole; suggests the ways of preventing ozone depletion.
	6	Student describes the oxygen cycle.
	10	Student lists sources, types and effects of air pollutants; plans an approach which allows preventing the air pollution.
MODULE 5. Water and water solutions	7	Student suggests the methods of the rational water management.
MODULE 6. Acid and bases	9	Student analyzes the process of the formation of acid rains and the effects of their actions, and suggests ways to limit their formation.
MODULE 8. Carbon and its compounds with hydrogen	1	Student lists the natural sources of hydrocarbons.*
	9	Student describes the properties and applications of polyethylene.*

*- Parts of module where environmental content is not precisely defined but certain issues can be represented

The content of the core curriculum should be taken literally [1]. This means that all items appearing in the certain topics are mandatory. At this stage of education, environmental teaching is focused basically on the main sources of pollution, the long-term effects of pollution, and the environment protection from the human activities effects. Environmental issues can be classified into four points: i) causes and effects of adverse changes in the atmosphere, hydrosphere and lithosphere; ii) the ways of the natural environment protection from the pollution; iii) threats resulting from the production and transportation of energy; iv) threats to the environment resulting from plastics and plastic waste recycling (optional).

Environmental issues in the new core curriculum at ISCED 3 level

Senior high schools are attended by the vast majority of the population in the age group 16-19/20 years and are administered by the district authorities. According to the new core curriculum, during 1st year at senior high school all students are obliged to perform chemistry course at basic level. The basic course is a natural continuation of chemistry course completed at ISCED 2 level. After this course, students who wish to major in science will continue their education at advanced course of chemistry. Considering the process of educational reform implementation, year 2012 is especially important - students, who had started junior high school with the new teaching program three years ago, took their final exams, and students of all types of senior high schools began the basic course of chemistry for the first time.

The environmental content provided by the learning outcomes of the curriculum at ISCED 3 of the basic level is defined by the following sentence: *II - Reasoning and application of acquired knowledge to solve problems. Student is aware of the properties connection of various substances with their usage, and their impact on the natural environment; uses acquired chemical knowledge in everyday life in the context of caring for personal health and the natural environment* [1]. The environmental knowledge and skills at this stage of teaching is gathered in four modules: i) the cleaning agents influence on the biosphere; ii) the soil degradation; iii) the energy sources and their impact on the natural

environment; iv) the management of waste from various sources. Details of environmental content at ISCED 3 level are listed below.

Table 3

The environmental content required by the core curriculum for chemistry at ISCED 3 level [1]

Curriculum module	Teaching content	
	No.	Detailed requirements
MODULE 2. Chemistry of cleaning agents	3	Student explains the reason for the elimination of phosphates(V) from the composition of washing powders (eutrophication process).
MODULE 4. Soil chemistry	3	Student lists the sources of soil chemical contamination and the basic types of contaminants (heavy metals, hydrocarbons, pesticides, nitrates).
	4	Student proposes the ways of protecting soil from degradation.
MODULE 5. Fuels - at present and in the future	4	Student proposes the alternative sources of energy - analyzes the possibilities of their applications (biofuels, hydrogen, solar power, water power, nuclear power, geothermal, etc.).
	5	Student analyzes the different ways of getting the energy influence on the state of the natural environment.
MODULE 6. Chemistry of packaging and clothing	2	Student classifies plastics according to their properties (thermoplastics and thermosets); writes equations of the chemical reaction for the synthesis of the PVC, indicates risks of gases generated by the combustion of the PVC.
	3	Student justifies the need for the management of waste from various packaging.

The implementation of obligatory environmental issues in analysed textbooks

The results obtained for the environmental content implementation study at ISCED 2 level are presented in Table 4. Most of environmental issues reviewed for this stage had satisfactory (C or A) correlation with the new core curriculum. Only in one case obligatory item was omitted, *ie* preventing ozone depletion in J02 case. Although the role of nitrogen oxides and chlorofluorocarbons (CFCs) in the ozone hole formation was described in this textbook, there was no explanation how the ozone depletion could be prevented or why the usage of CFCs was restricted. In all examined textbooks terms such as the greenhouse effect, smoky fog and acid rains were discussed. The analysis of rational water management issue revealed that removal of water contaminants and prevention of water pollution were considered in all the textbooks. The term of water treatment plant were omitted in two cases (J02 and J03) and sewage treatment plant was not discussed in J02. On the other hand, extracurricular sources and effects of water pollution were described in detail by all textbooks. Noteworthy is general lack of questions in Modules: 4 (except J03) and 5. All textbooks dealt with the acid rains issue quite extensively. Interestingly, the investigation of plastic waste problems, pollution caused by petroleum leakage and toxicity of carbon monoxide exhibited that such additional topics were raised in some textbooks.

The results for ISCED 3 level study revealed almost excellent coherence with the curriculum for S01, S02 and S04 textbooks (Table 5). In all analyzed textbooks students may find explanation for the elimination of phosphates(V) from the composition of washing powders. Contamination of soil issue was also discussed accurately in all textbooks. It is worth noting that all analysed textbooks had plenty of graphical representations and tasks for alternative sources of energy (except S03). In contrast, indicating the risk of gases generated by the combustion of the PVC was explained very

briefly in S03. The description of waste management from various materials should be regarded as satisfactory in all cases, especially that chemistry curriculum does not mention terms such as waste segregation, recycling or biodegradation. The comprehension section of Module 6 could be better for S03 and S04.

Table 4
The coherence of environmental content in analyzed textbooks with the core curriculum requirements at ISCED 2 level

Curriculum modules	Textbooks											
	J01			J02			J03			J04		
	Coh. ^a	Ill. ^b	Q ^c	Coh. ^a	Ill. ^b	Q ^c	Coh. ^a	Ill. ^b	Q ^c	Coh. ^a	Ill. ^b	Q ^c
MODULE 4. Air and other gases												
The formation of the ozone hole	C	1	0	C	2	0	C	0	2	C	2	1
The ways of preventing ozone depletion	A	1	0	NP	0	0	A	0	1	C	1	0
The oxygen cycle	C	1	0	C	1	0	C	2	3	C	2	0
Sources, types and effects of air pollution:	C	8	2	C	3	2	C	6	2	C	2	2
- Greenhouse effect*	+	1	1	+	2	2	+	1	2	+	2	2
- Smoky fog*	+	1	1	+	1	0	+	2	1	+	1	1
- Acid rains*	+	0	1	+	0	0	+	1	0	+	1	1
The ways of protecting the air from pollution	C	0	1	C	0	2	C	0	2	C	0	2
MODULE 5. Water and water solutions												
The methods of rational water management	A	1	0	A	0	0	C	0	0	C	0	1
Sources of water pollution*	+	2	0	+	1	0	+	2	0	+	2	0
The effects of water pollution*	+	2	4	+	0	0	+	1	0	+	1	0
Removal of water contaminants	C	2	0	A	0	0	C	0	0	C	1	1
- Sewage treatment plant*	+	1	0	-	-	0	+	0	0	+	1	0
- Water treatment plant*	+	1	0	-	-	1	-	-	-	+	1	1
The prevention of water pollution	C	0	1	A	0	1	C	0	1	A	1	1
MODULE 6. Acid and bases												
The process of the formation of acid rains	C	1	0	C	0	0	C	3	2	C	1	3
The effects of acid rains' actions	C	4	3	C	1	1	C	2	0	C	2	0
The methods of reducing acid rains' formation	A	0	0	A	0	0	C	0	1	C	0	1
MODULE 8. Carbon and its compounds with hydrogen												
The natural sources of hydrocarbons:												
- Pollution caused by petroleum*	+	2	0	-	-	-	P ⁱ	-	-	P ⁱ	-	-
- Toxicity of carbon monoxide*	+	1	0	+	0	1	+	0	0	+	0	0
The properties and applications of polyethylene (plastic waste recycling, biodegradation)*	+	0	1	+	0	1	+	1	2	+	1	-

Where: ^a Coh. - coherence; ^b Ill. - number of illustrations; ^c Q - number of related questions; C - this item is present and its description is extensive; A - this item is present and its description is concise; P - this item is only slightly mentioned; NP - this item is not present in the textbook; * - optional topic; "+" - extracurricular item is present; "-" - extracurricular item is absent; ⁱ - this item was mentioned in different chapter. Caution: some illustrations and questions were counted more than once as they were related to more than one item.

In our opinion, the curriculum for subject chemistry includes teaching content for ISCED 2 and ISCED 3 stages, which is sufficient in providing knowledge and skills necessary for proper environmental education. However, in some cases curriculum probably left too much freedom for textbooks' authors, thus some mandatory topics were

commented very shortly (*eg* preventing ozone hole) and others were full of illustrations and various tasks to solve (*eg* fuels).

Table 5

The coherence of environmental content in analyzed textbooks with the core curriculum requirements at ISCED 3 basic level

Curriculum modules	Textbooks											
	S01			S02			S03			S04		
	Coh. ^a	Ill. ^b	Q ^c	Coh. ^a	Ill. ^b	Q ^c	Coh. ^a	Ill. ^b	Q ^c	Coh. ^a	Ill. ^b	Q ^c
MODULE 2. Chemistry of cleaning agents												
The reason for the elimination of phosphates(V) from the composition of washing powders (eutrophication process)	C	1	3	C	1	1	C	2	2	C	1	1
MODULE 4. Soil chemistry												
The sources of chemical contamination of soils	C	4	1	C	6	1	C	2	0	C	3	2
Basic types of contaminants (heavy metals, hydrocarbons, pesticides, nitrates)	C	4	3	C	3	1	C	1	0	A	4	1
The ways of protecting soil from degradation	C	3	1	C	3	2	C	1	3	C	2	1
MODULE 5. Fuels - at present and in the future												
The alternative sources of energy and the possibilities of their applications	C	11	3	C	20	8	A	1	0	C	10	1
- biofuels, hydrogen, nuclear power	C	5	1	C	14	7	A	1	0	C	7	3
- solar power, water power, geothermal, etc.	C	5	1	C	14	9	A	1	0	C	3	1
The influence of different ways of getting the energy on the state of the natural environment	C	3	1	C	8	8	C	5	3	C	3	1
MODULE 6. Chemistry of packaging and clothing												
Classification of plastics according to their properties (thermoplastics and thermosets)	C	0	2	C	2	0	C	3	1	C	3	0
Indicating the risks of gases generated by the combustion of the PVC	C	1	1	C	0	1	P	0	0	C	2	1
Justifying the need for the management of waste from various packaging	C	3	1	C	1	2	A	0	0	C	1	0
The ways of waste segregation*	+	6	2	C	1	1	+	2	2	+	1	0
Paper recycling*	+	2	1	+	1	1	+	1	1	+	1	0
Glass recycling, selective collection*	+	2	1	+	3	0	+	1	1	+	1	0
Metal recycling*	+	3	2	+	2	1	+	1	1	+	2	0
Plastic waste recycling, biodegradation*	+	9	2	+	3	0	+	4	2	+	3	1

Where: ^a Coh. - coherence; ^b Ill. - number of illustrations; ^c Q - number of related questions; C - this item is present and its description is extensive; A - this item is present and its description is concise; P - this item is only slightly mentioned; * - optional topic; "+" - extracurricular item is present; ⁱ - this item was mentioned in different chapter. Caution: some illustrations and questions were counted more than once as they were related to more than one item.

Conclusions

The new core curriculum for chemistry subject is sufficient in providing awareness of environmental problems among Polish students. The results of this comprehensive study show that all examined textbooks were coherent with environmental issues included in the core curriculum. Most of mandatory topics analyzed in this study had extensive or concise description. We have noticed only two cases where the required items were omitted or slightly mentioned. It is a matter of discussion, whether certain items in the new core curriculum should be more specific to avoid overloading textbooks with huge amount of

information without paying enough attention to obligatory issues, *eg* the rational water management or the waste management from various sources.

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ELEMENTY EDUKACJI PROŚRODOWISKOWEJ W NOWEJ PODSTAWIE PROGRAMOWEJ PRZEDMIOTU CHEMIA ORAZ W WYBRANYCH PODRĘCZNIKACH DO NAUCZANIA CHEMII DLA III I IV ETAPU KSZTAŁCENIA

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Abstrakt: W 2009 roku Ministerstwo Edukacji Narodowej wprowadziło nową podstawę programową kształcenia ogólnego w Polsce, która przekształciła całkowicie edukację środowiskową na III (gimnazjum) i IV (szkoły ponadgimnazjalne) etapie kształcenia. Biorąc pod uwagę ogromny wpływ substancji chemicznych na stan środowiska naturalnego, podstawa programowa przedmiotu chemia pełni istotną rolę w rozwijaniu wiedzy środowiskowej oraz postaw prośrodowiskowych wśród uczniów polskich szkół. Bez wątpienia, podręczniki chemiczne są nie tylko podstawowym źródłem wiedzy naukowej dla uczniów, ale także inspiracją dla nauczycieli przygotowujących zajęcia lekcyjne. Reforma edukacyjna narzuciła konieczność zaktualizowania podręczników do nauki chemii zgodnie z nową podstawą programową. Celem niniejszej pracy było zbadanie spójności elementów edukacji prośrodowiskowej wymaganych w nowej podstawie programowej z omówieniem tych zagadnień zaproponowanym w wybranych podręcznikach. Analizie poddano podręczniki dla szkół gimnazjalnych i ponadgimnazjalnych (zakres podstawowy) wydane przez największe polskie wydawnictwa edukacyjne. Wyniki tego badania wskazują, że wszystkie analizowane podręczniki są zgodne z treściami kształcenia prośrodowiskowego zawartymi w podstawie programowej, a jeśli to konieczne, zawierają także dodatkowe wiadomości nieujęte podstawą programową (np. problemy z odpadami związków organicznych). Porównanie

wybranych podręczników dostarczyło informacji o stanie obecnym wdrażania reformy edukacyjnej oraz o elementach nowej podstawy programowej dotyczących problemów środowiskowych, które warto poprawić lub uściślić.

Słowa kluczowe: edukacja prośrodowiskowa, postawa prośrodowiskowa, nowa podstawa programowa, podręczniki chemiczne