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Rusty soils – “lost” in school education

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Abstract

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Rusty soils cover about 15% of Poland's territory and they are the most important type of soil used in the forest management. Polish soil scientists know these soils very well but, unfortunately it seems, that students who come to environmental studies know very little about them—less than about other soil units. Does electing rusty soil as the Polish Soil of the Year 2021 present an opportunity to change that? The aim of this paper is to diagnose what is the availability of information on rusty soils at the level of education in secondary schools and what is the state of knowledge about these soils in the broad non-academic community. Three main research methods were used: querying geography textbooks, querying internet sources and survey method. Information on rusty soils is rather not presented in textbooks. Of the 17 analysed websites – 8 lack any information on those soils. Coefficient of Information Availability (CIA) for rusty soils is one of two lowest among all studied units. Respondents assessed the knowledge of rusty soils lower than most of other Polish soils but they would like to learn more about them. Additionally, the low level of knowledge about it does not reduce its recognition: respondents had no problem to recognize rusty soil on the base of photograph and to distinguish the correct number of genetic horizons. The Year of Rusty Soil is a great opportunity to introduce young people to these soils. Field lessons can combine soil education with ecological issues. Rusty soils can be seen as optimal choice for these activities. These soils could be an perfect type to increase public awareness of soils at all but especially with regard to common soils important to our local environment.

1. Introduction

Soil is one of the most important component of terrestrial ecosystems but at the same time it is relatively poorly known to a wide community. One of the challenges of the modern world is to increase social awareness of the environment, including soil cover. People should know that soils are important in the production of biomass, food, fiber, and fuel (Cruse et al., 2013), in the hydrological cycle (Brevik, 2009), a support for ecological habitats and biodiversity (Blum, 2005), in a struggle against many forms of pollution (Jones et al., 2012) and their contribution to carbon sequestration (Jones et al., 2012; Crossman et al., 2013; Lal and Stewart, 2013). They are a source of materials for building and infrastructures (Jones et al., 2012; Pritchard et al., 2014) and provide a preservation for past cultural landscapes and artifacts (Kibblewhite et al., 2015; Urbańska and Charzyński, 2021). The Polish Soil Science Society is, among other things, a promoter of soil science knowledge in Poland. The organization try to draw the public's attention to soils by promoting them (creating an appropriate logos, banners and posters) as well as encouraging scientists to further research on many types of soils

and publishing their results. These activities are aimed not only at soil scientists but also at a wider audience (teachers, pupils and students). In previous years the Polish Soil of the Year was chosen to spread knowledge about the selected type to a larger audience. The Soils of the Year were: Rendzinas (2018), Chernozems (2019) and Technosol (2020). These activities did not attract the attention of the non-academic community. Only rusty soil – Soil of the Year 2021 aroused enormous media attention. Information appeared in the TV news programs (“Contact Mirror” on the TVN 24 station, TVP 1, Polsat News) it was also widely commented on Facebook (265 comments and 400 shares, as of 12th February 2021), Twitter and Instagram. These sandy soils are typical for post-glacial areas of the temperate climate zone. Rusty soils cover about 15% of Poland's territory and they are the most important type of soil used in the forest management. Usually they are formed from loose and slightly loamy sandy deposits of various origins. Rusty soils are formed under the vegetation of poorer variants of deciduous forests as well as mixed forests. However, in many places they are planted with monoculture pine crops, causing change on their properties and their degradation. Rusty soils are one of the most important, basic

components of soil cover, which has long been studied by many soil scientists (Bednarek, 1991, Jankowski, 2003, 2014; Rosa et al., 2019; Kobierski et al., 2020). Polish soil scientists know these soils very well but, unfortunately it seems, that students who come to environmental studies know very little about them—less than about other soil units. Is it just the lecturers' impression? Are rusty soils not mentioned in currently used school textbooks? Does identifying rusty soil as the Soil of the Year present an opportunity to change that? The aim of this paper is to diagnose what is the availability of information on rusty soils at the level of education in secondary schools and what is the state of knowledge about these soils in the broad non-academic community. The authors set the following research tasks:

- review (querying) and evaluation of information contained in school textbooks and educational websites;
- checking the state of non-academic society's knowledge of rusty soils;
- assessment of the suitability of the discussed soils in the educational process- especially in the context of field works for high school students.

2. Materials and methods

Three main research methods were used: querying geography textbooks, querying internet sources and survey method.

2.1. Querying geography textbooks/websites

The content of high school geography textbooks was analyzed in terms of the knowledge offered in the field of rusty soils. Currently, only two publishing houses in Poland offer textbooks intended for teaching geography in high school at the extended level: Operon and Nowa Era. However, the content of 14 textbooks and 3 geographical repertories were analyzed (Table 1).

As well as the textbooks the Internet resources were analyzed in the light of available information of rusty soils (Table 1). 17 websites were analyzed (first 17 results; search date: 18th April 2021) after the entry: "soils of Poland" (gleby Polski) in the *google* search engine). However, it should be noted that the results depend on the history of previous searches so they can vary from user to user. Nevertheless, in all sources (textbooks and websites) information was analyzed for 9 main soil types in Poland: clay-illuvial, brown, podzolic and rusty soils as well as chernozems, black earths, alluvial soils, rendzinas and peat soils. The frequency of four kinds of information (categories) was the basis for assigning "information scores" within each type of soil: a) names of these soils – multiplied by 1 point, b) their properties x 2 points, c) profiles–photo or scheme x 3 points and d) description of soil sequences x 3 points. **Coefficient of Information Availability (CIA)** providing general access in textbooks/websites to educational information on each nine types of soils is the sum of the **Partial Coefficient of Information Availability (CIA_p)** values calculated for every of four information categories (a, b, c, d). The CIA_p was calculated according to elaborated

formula: $CIA_p = \sqrt{\frac{Ti}{Tt}} \times ip$ (CIA_p – the Partial **Coefficient of**

Information Availability; Ti – the number of textbooks/websites with soil information; Tt – the total number of textbooks/websites; ip – sum of "information points" in particular categories.

2.2. The survey method

The data collected from survey aims to evaluate soil awareness level. It consisted random selection of participants based on non-probability sampling who were not related to soil science (non-academic society). The survey consisted of 4 questions relating to the mentioned above 9 types of soils:

- How do you estimate your knowledge of each of the mentioned soils (on a scale from 1 to 5)? (Self-Assessment of Knowledge index)
- Are the following soil names intriguing / interesting for you and would you like to learn more about them?
- The photos show 4 different soils. How many distinct soil horizons (layers) do you see in each of them?
- Try to match the soil name (all 9 main types were possible to choose from) with the photo.

The last two questions are accompanied by photos of the soils – podzolic, brown, rusty and clay-illuvial profiles.

Moreover, the questionnaire included information about the respondents (age, sex, place of residence). A total of 420 respondents participated in the study to answer questions about their soil awareness in the context of rusty soils. The participants included 40,4% males and 59,6% females. 70,1% of respondents were urban and 29,9% rural residents.

Survey was conducted via Internet and then collected for data analysis. The study was based on the results of a survey addressed to a diverse group of recipients (employment, students, schoolchildren) who are not professionally involved in soil science. The questionnaire was constructed as a "Google Form" and sent to recipients via e-mail or distributed through social media. Answers were analyzed using a quantitative approach to investigate the knowledge about rusty soils.

3. Results and discussion

Rusty soils are common in Poland, and they were recognized many years ago—they were officially distinguished in Polish Soils Classification as soil type almost 50 years ago (PSC, 1974). Nevertheless, the textbooks as well as websites have little information about them (Fig. 1). They are the only ones in the group of common (occupy more than 10% of country area), zonal soils with low CIA. Moreover, information on rusty soils is totally not presented in six out of 17 textbooks. There is no difference between information in the older and most recent ones. Only two textbooks (from 1999 and 2013) have a soil profile with a description of rusty soil morphology. Of the 17 analyzed websites – 8 lack any information on rusty soils. Only one website (geografia24.eu) gives relatively detailed knowledge of rusty soil characteristics and profile. Moreover, the name "rusty soil" occurs there six times. This is an excellent result because, according to a website query, information on rusty soils available on the Internet for

Table 1

Textbooks, geographical repertories list and Internet sources

Title	Author	Year of publication	Publishing House
Geography of Poland. Textbook for X class,	Barbag J., Janiszewski M.	1964	Państwowe Zakłady Wydawnictw Szkolnych. Warsaw (in Polish)
Geography of Poland. Textbook for II class of high school and economic school.	Batorowicz Z., Górecka Ł., Prokopek B.	1970	Państwowe Zakłady Wydawnictw Szkolnych. Warsaw (in Polish)
Physical geography with geology. Textbook for high school.	Stankowski W.	1987	Wydawnictwa Szkolne i Pedagogiczne. Warsaw (in Polish)
Geography. Textbook for basic vocational school.	Domachowski R., Makowska D.	1987	Wydawnictwa Szkolne i Pedagogiczne. Warsaw (in Polish)
Poland i Europe. Geography textbook for high school.	Batorowicz Z., Nalewajko J., Suliborski A.	1990	Wydawnictwa Szkolne i Pedagogiczne. Warsaw (in Polish)
The Earth and people. Physical geography textbook for high school.	Makowska D.	1998	Wydawnictwa Szkolne i Pedagogiczne. Warsaw (in Polish)
Geography of Poland.	Świtalski E., Preisner Z.	1999	Oficyna Wydawnicza Turpress” Torun [In [Polish]
Outline of knowledge about the Earth. Textbook for high school.	Podgórski Z., Marszelewski W., Becmer K.	2002	Wydawnictwa Szkolne i Pedagogiczne. Warsaw (in Polish)
Physical geography 1. Extended level. Textbook for high school.	Czubla P., Papińska E.	2003	PWN WydawnictwoSzkolne. Warsaw (in Polish)
Geography of Poland. Textbook for high school.	Krynicka-Tarnacka T., Wnuk G.	2005	SOP. Torun (in Polish)
Geography 1. Basic level.	Kop J., Kucharska M., Szkurlat E.	2006	PWN Wydawnictwo Szkolne. Warsaw (in Polish)
Geography. Vademecum.	Stasiak J., Zaniewicz Z.	2013	Wydawnictwo Pedagogiczne Operon. Gdynia (in Polish)
Faces of geography 3. Textbook for high school and technical school. Extended level.	Więckowski M., Malarz R.	2014	Nowa Era. Warsaw (in Polish)
Geography. Repertory for high school graduates.	Biłgoras J., Głowacz A., Koperska-Puskarz D., Mazur M., Mozolewska-Adamczyk M., Srokosz W., Zieliński K.	2014	Wydawnictwa Szkolne i Pedagogiczne. Warsaw (in Polish)
Geography. Repertory for high school graduates.	Łękawa A.	2015	Greg. Cracow (in Polish)
Faces of geography 1. Textbook for high school and technical school. Extended level.	Malarz R., Więckowski R., Kroh P.	2019	Nowa Era. Warsaw (in Polish)
Geography-extended level. Textbook for high school.	Kurek S.	2019	Wydawnictwo Pedagogiczne Operon. Gdynia (in Polish)
Internet sources			
https://epodreczniki.pl/a/zroznicowanie-gleb-i-roslinnosci-na-obszarze-polski/DSM0RxnIH (website 1)			
https://www.ekologia.pl/wiedza/slowniki/leksykon-ekologii-i-ochrony-srodowiska/ (website 2)			
https://pracownik.kul.pl/files/32723/public/pdf/gleba.pdf (website 3)			
https://eszkola.pl/geografia/rozmieszczenie-gleb-w-polsce-6778.html https://www.edukator.pl/resources/page/gleby/11165 (website 4)			
https://matura100procent.pl/rozmieszczenie-gleb-na-swiecie/ https://geografia.gozych.edu.pl/gleby-w-polsce/ (website 5)			
https://opracowania.pl/opracowania/geografia/gleby-w-polsce,oid,1729 https://www.naukowiec.org/wiedza/geografia/gleby-w-polsce-rodzaje_3403.html (website 6)			
https://www.bryk.pl/wypracowania/geografia/geografia-fizyczna/8387-gleby-polski.html http://geografia24.pl/gleby-w-polsce/ (website 7)			
https://swiatrolnika.info/gleby-w-polsce-rolnictwo (website 8)			
https://www.geografia24.eu/geo_prezentacje_rozsz_3/383_1_srodowisko_przyrodnicze/r3_1_08a.pdf (website 9)			
https://geografia.na6.pl/warstwa-glebowa (website 10)			
https://sciaga.pl/tekst/39463-40-gleby_w_polsce (website 11)			
http://geomorawa.ucoz.pl/publ/gleby_i_roslinnosc_polski/1-1-0-228 (website 12)			
http://www.pcez-bytow.pl/download/plk/gleby-w-polsce.pdf (website 13)			
https://www.edukator.pl/resources/page/gleby/11165 (website 14)			
https://geografia.gozych.edu.pl/gleby-w-polsce/ (website 15)			
https://www.naukowiec.org/wiedza/geografia/gleby-w-polsce-rodzaje_3403.html (website 16)			
http://geografia24.pl/gleby-w-polsce/ (website 17)			

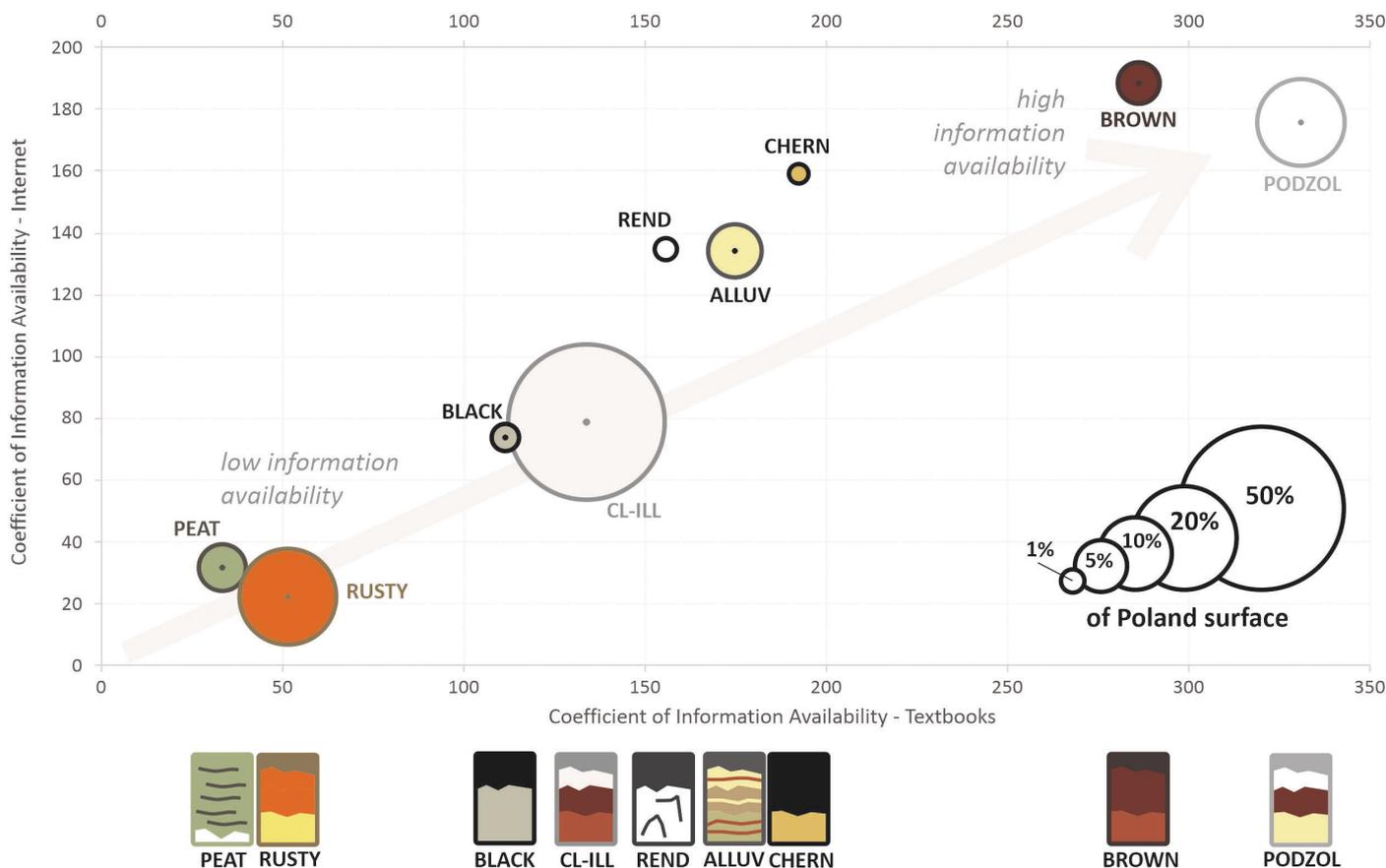


Fig. 1. Comparison of the Coefficient of Information Availability (CIA) of main soil types (CLay-ILLuvial, BROWN, PODZOLic, RUSTY soils, CHERNOzems, BLACK earths, ALLUVial soils, RENDzinas and PEAT soils) in textbooks and Internet

the average finder is even more scarce than in textbooks. While websites are often created by anonymous authors and are characterized by numerous mistakes and omissions about soils of Poland (Świtoniak et al., 2018), the textbooks should contain correct, professional information in accordance with the current state of knowledge. The only one textbook providing up-to-date information about share of particular soil types is book written for children for Polish emigrants in Norway (Mazurek-Daves, 2019) as it doesn't have to follow Polish School Curriculum. The lack of educational information on rusty soils is probably inherited from the period before 1970s when rusty soils were treated as sandy brown soils (Świtoniak et al., 2019) and educational 'inertia' – the lack of updating the school curricula and thus content of the textbooks in line with the progress of knowledge. It should be noted that research conducted in the Polish Lowlands has shown that the so-called "brown soils" developed from morainic, loamy deposits are in fact eroded clay-illuvial soils (Kobierski, 2013; Podlasiński, 2013; Świtoniak, 2014; Świtoniak et al., 2016, 2019). Similar phenomena were also noticed in south part of the country (Rodzik et al., 2014; Loba et al., 2021). For these two reasons there are almost no such type of soils in the Poland. However, in textbooks and websites, information about the brown soils (together with podzolic soils) still dominate. It is present in all textbooks and websites and as many as 13 textbooks and 7 websites have its soil profile. 16 from 17 websites

describe brown soil in detail. It is necessary to introduce an amendment stating that the soils are not brown but eroded clay-illuvial soils (Świtoniak, 2006, 2007, 2011). This is the key ecological and functional information and should be communicated to a wider audience.

How, then, did the respondents describe their knowledge (Self-Assessment of Knowledge index) of rusty soils? Does it reflect the low level of availability of information about them? The analysis of the respondents' answers showed that rusty soil is almost the worst in this comparison (Table 2). Respondents assessed lower only the knowledge of rendzinas (which are local soils with an average CIA. Interestingly, the highest values of the Self-Assessment of Knowledge index have soils with the highest CIA (brown and podzolic soils). Chernozems and peat soils with a low CIA achieved also high Self-Assessment of Knowledge index but their names are well known from everyday life – they are associated with the urban agriculture, e.g. cultivation of gardens and the care of plants.

It is interesting to know if respondents would like to learn more about rusty soils despite the low level of knowledge. Figure 2 answers this question. Rusty soil was not among the leaders (alluvial soils and chernozems are) but it is in the group of soils of considerable interest (+59 – together with rendzinas and peat soils) and stands out among all zonal soils in Poland – 1st place in zonal, ahead of brown, podzolic and clay-illuvial soils.

Table 2
Self-assessment of knowledge about specific soil types

		Soil type									
		Chernozem	Black soil	Brown soil	Clay-illuvial	Rusty soil	Podzol	Alluvial soil	Rendzina	Peaty soil	
Age	number of respondents										
0–15	40	2.08	1.73	1.83	1.45	1.30	1.53	1.43	1.10	1.68	
16–20	131	2.42	1.87	2.16	1.79	1.54	2.09	2.00	1.63	2.11	
21–25	73	2.22	1.85	2.07	1.67	1.74	1.93	1.74	1.40	2.05	
26–40	96	2.00	1.55	1.64	1.27	1.29	1.45	1.38	1.09	2.00	
>41 years	79	2.10	1.46	1.65	1.41	1.23	1.48	1.47	1.18	2.20	
	Total 420	Mean:	2.20	1.70	1.89	1.55	1.44	1.75	1.66	1.33	2.05

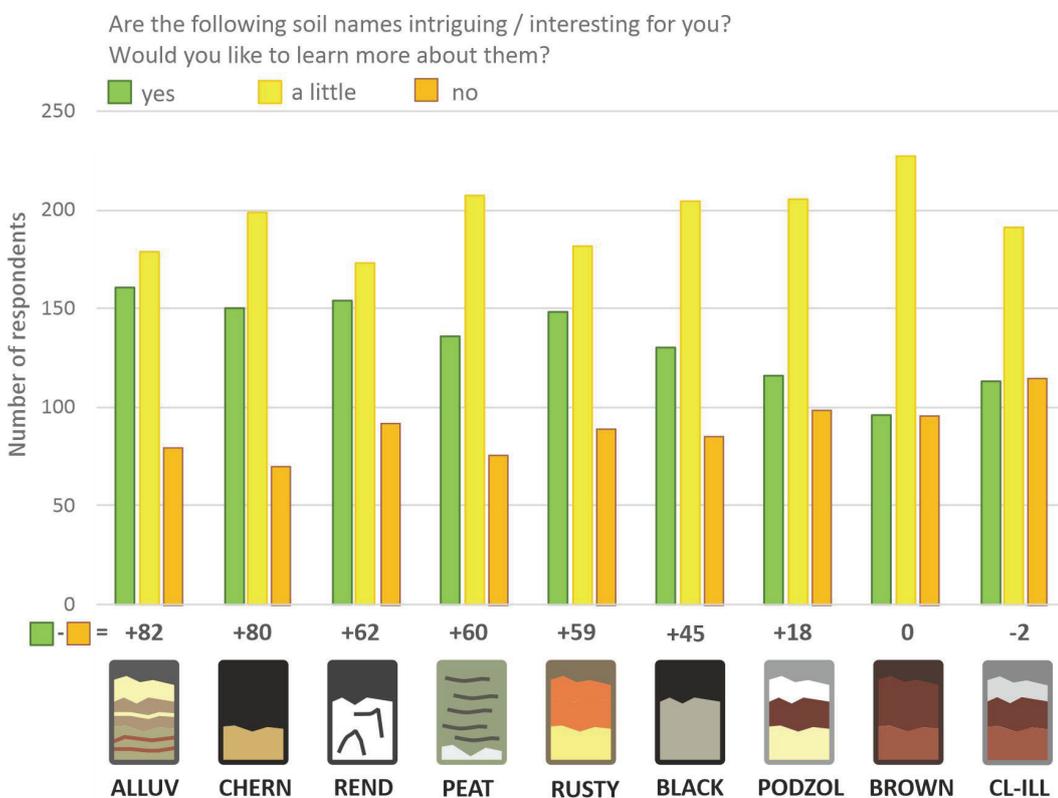


Fig. 2. The respondents' curiosity about the studied soils (CLay-ILLuvial, BROWN, PODZOLic, RUSTY soils, CHERNozems, BLACK earths, ALLUVial soils, RENDzinas and PEAT soils)

An attempt was made to indicate whether the rusty soil is easily recognizable based on their morphology. Despite the very poor transfer of information at the level of school education, the interest in these soils is significant. Additionally, the low level of knowledge about it does not reduce its recognition (Fig. 3). The characteristic orange-brown color is undoubtedly a great asset. As many as 34% of respondents recognized rusty soil which puts it on a par with the recognition of soils most often described in textbooks – podzolic and brown soils (Fig. 3). Interestingly, rusty soils are most often confused with clay-illu-

vial and podzolic soil – which is difficult to explain. Except that as many as 17% of respondents confused brown soil (eroded clay-illuvial soil in fact) with rusty soil – probably due to the similar colors of these soils. The worst situation (7% of correct indications) concerns fully developed clay-illuvial soils and it is the limit of statistical randomness. This is an unfavorable and dangerous situation from the point of view of education. These soils are the basis of the Polish agricultural economy and near 50% of the country and they should be much better recognizable (Sykuła et al., 2019).

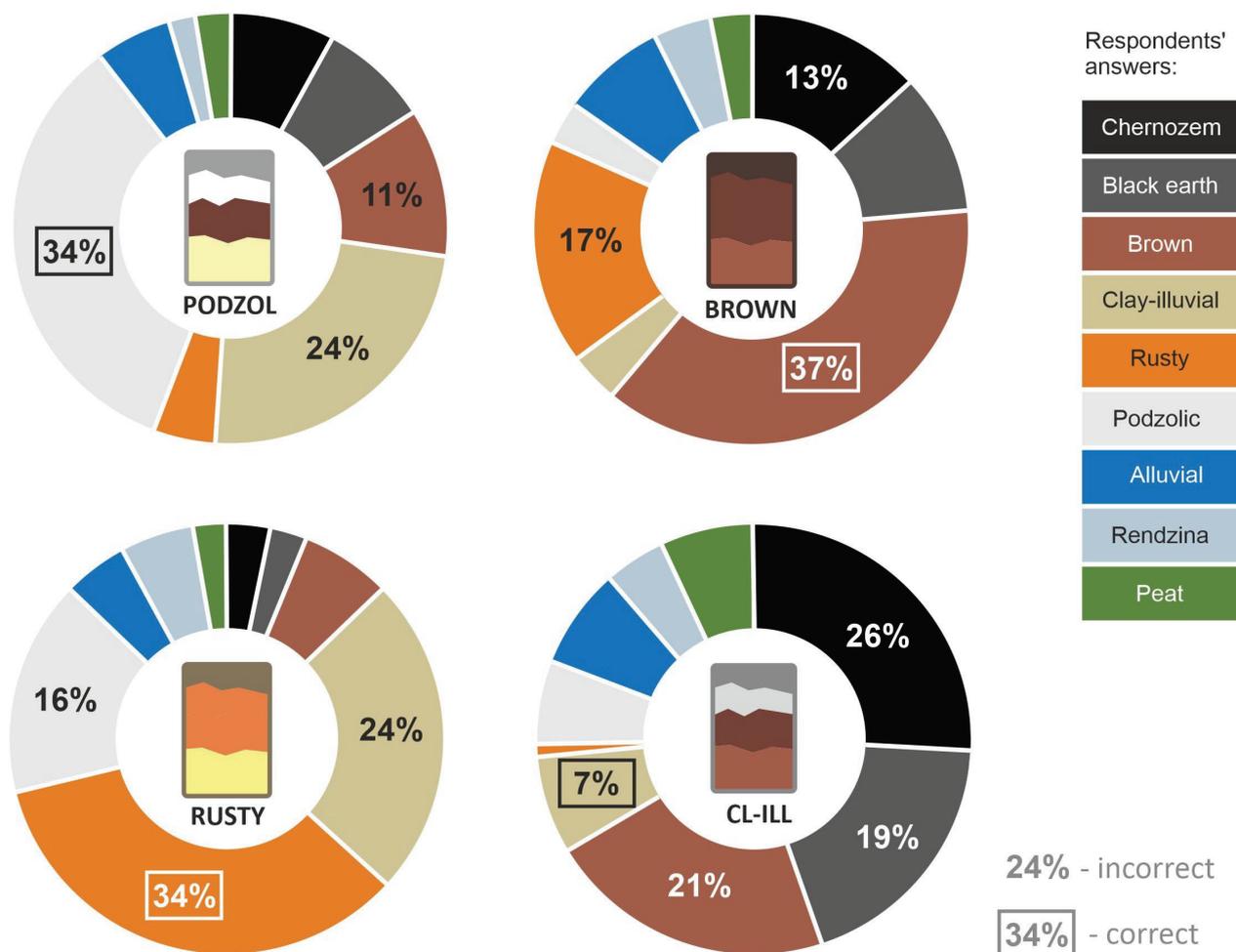


Fig. 3. Recognition of soil types (CLay-ILLuvial, BROWN, PODZOLic, RUSTY soils)

The relatively high recognizability of rusty soils is certainly due to its characteristic (even intuitive) morphology. This is confirmed not only by the correct naming of the soil type, but also by the highest percentage of respondents who indicated the proper number of soil horizons (Fig. 4). The A-B-C morphology is easy to identify even for people not related to soil science. Over 50% of the respondents had no problem pointing to the correct number of horizons. However, in rusty soil, as in brown soil, there is a tendency to omit (underestimate) certain horizons. Quite the opposite as in the case of soils with the morphology A-E-B-C where the respondents overestimated the number of horizons.

Various factors may have contributed to the increased curiosity about rusty soils. The campaign Soil of the Year had a great impact on the media (TV, FB analysis) which resulted in an increase in the search for the phrase “rusty soil” at the beginning of February 2021 (Fig. 5). This fact is confirmed by the analysis of google trends. They do not have such statistics as chernozems or peat soils but the interest in rusty soils in the network has definitely increased in recent times.

It is important to state if the rusty soils have high value for the educational process, e.g. in the context of the possibility of conducting field works with pupils? In authors opinion, among

the analyzed soils, rusty ones are the most favorable (Table 3). They are quite common – easy to find for teachers in almost all parts of Poland and also easily recognizable. Moreover, due to its sandy nature it is relatively easy to dig a soil pit. Their genesis can be clearly explained and understood—they have a simple and very expressive morphology, intuitively recognizable by people not related to soil science (Fig. 3, 4). Only the podzolic soils have a similar usefulness but unfortunately in most of them the podzolization is not enough clear and easy to explain for pupils because is superimposed on the rust-forming process as a pinetization effect (due to the pine reforestation). Changes in the nature of vegetation caused changes in the soil profile. Despite the fact that rusty soils have been “forgotten” in textbooks a lot of information about them can be found on the website of the Polish Soil Science Society. Interesting multimedia materials that can be used in rusty soil education is the portal created in relation to the FACES Erasmus+ project (website 18) as well as soil database (website 19). Using the educational resources is possible to successfully implement the provisions included in the core curriculum with reference to the analysis of spatial distribution of soils and the impact of vegetation, climate or anthropopressure on their development and degradation (Urbańska et al., 2019).

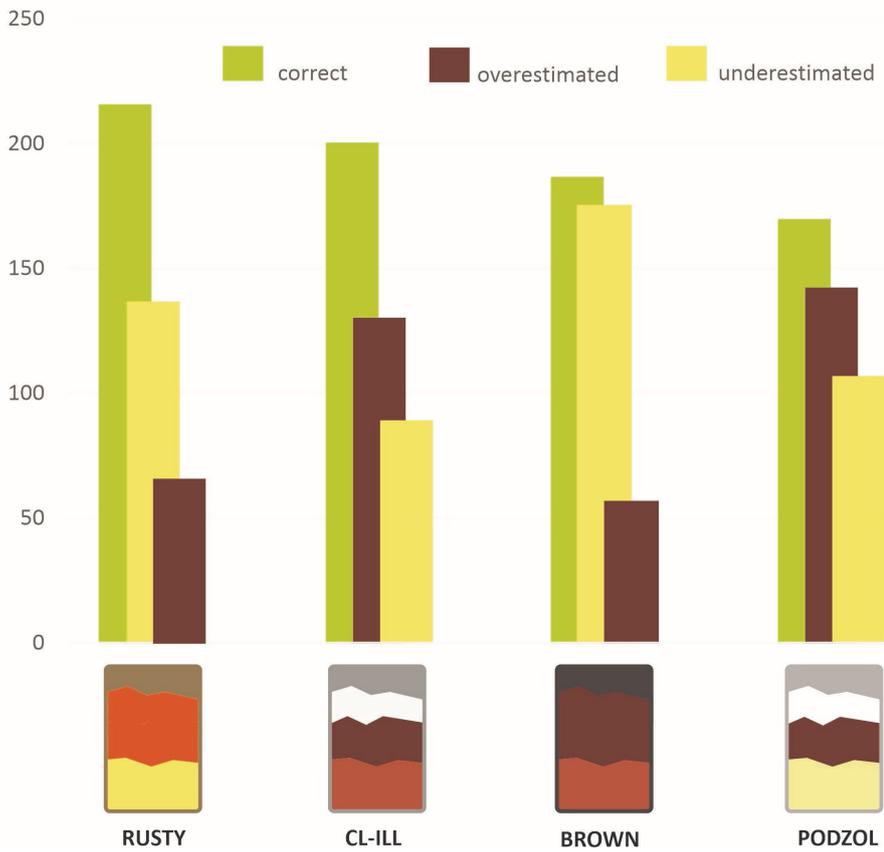


Fig. 4. Recognition of the number of genetic horizons (CLay-ILLuvial, BROWN, PODZOLic, RUSTY soils)

<https://trends.google.com/> - 30.03.2021

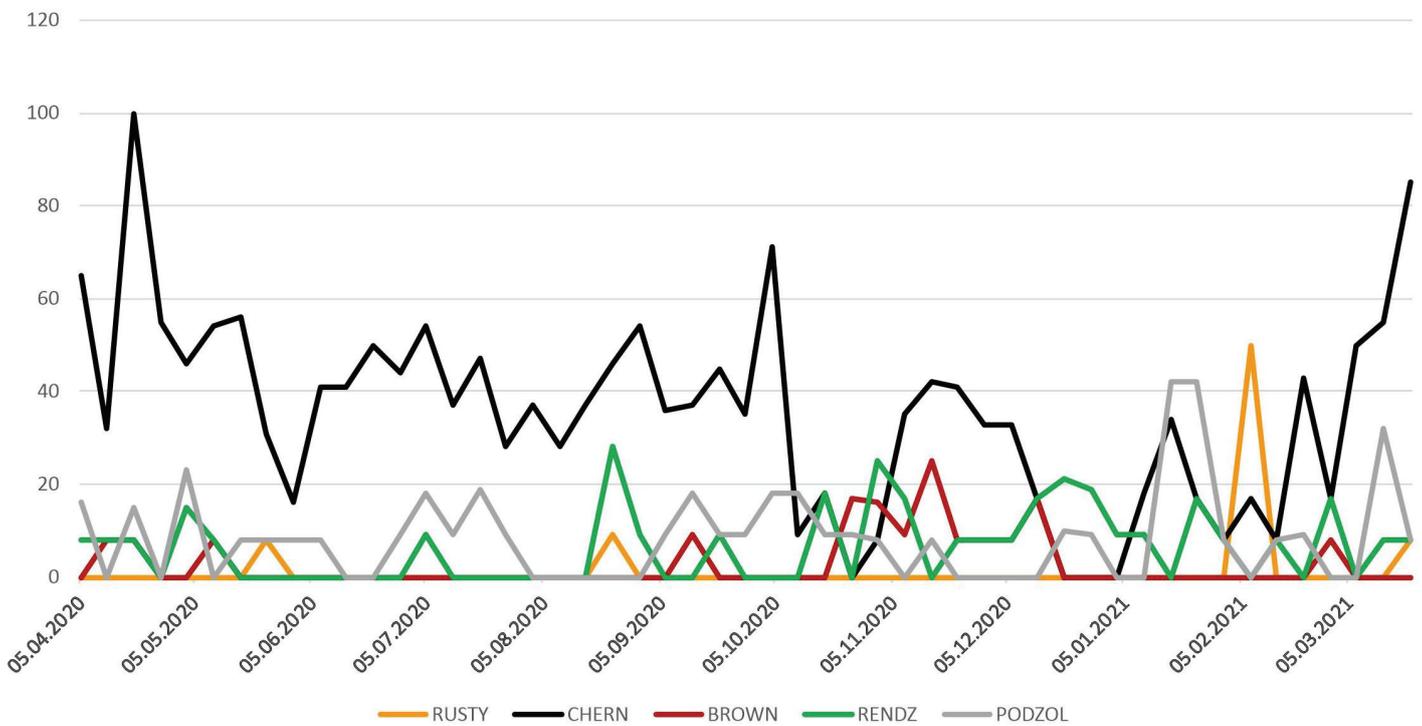


Fig. 5. The viral impact of rusty soils (FB post) on internet interest

Table 3

The utility of soil types in education

Soil type	Chernozem	Black soil	Brown soil	Clay-illuvial	Rusty soil	Podzol	Alluvial soil	Rendzina	Peaty soil
Utility in education									
Frequency of occurrence	-	-	-	+	+	+	-	-	-
Recognizability	+	+	-	-	+	+	+	+	+
Soil pit preparing	-	-	-	+	+	+	-	-	-
Understanding of pedogenesis	+	+	-	-	+	+	+	+	+

4. Conclusions

The Year of Rusty Soil is a great opportunity to introduce young people to these soils. It shall start with update of National Curricula and, according to the latest scientific knowledge, information on brown soils should be also updated. Brown soils should “give way” to more common soils (clay-illuvial and rusty soils). Soils should not only achieve better scientific understanding but also they should be treated as crucial element of human wellbeing. There are significant developments in the perception of both the ecological and non-ecological functions of soils in providing fundamental ecosystem services (Blum, 2005; Jones et al., 2012; Crossman et al., 2013; Lal and Stewart, 2013; Morel et al., 2015; Baveye et al., 2016). Students are aware of many risks and problems like global warming and air pollution but they are not sufficiently informed that soil resources and soil protection are equally important for their existence. Field lessons can combine soil education with ecological education and at the same time constitute a kind of excursion. Rusty soils can be seen as optimal choice for these activities. To sum up, rusty soils:

1. cover a large percentage of Poland's territory. They are therefore easily accessible and, moreover, easy to mechanically dig out the soil pits due to the sandy material;
2. are intuitively and easily recognizable and their genesis is easy to explain;
3. are of great interest among the public which may be related to the name of these soils (rusty) referring to other, well-known processes (iron /steel/car rusting);
4. are hardly ever present in school education (as well as clay-illuvial soils).

Rusty soils could be an ideal choice to increase public awareness of soils at all but especially with regard to common soils important to our local environment.

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Gleby rdzawe – przeoczone w edukacji szkolnej

Słowa kluczowe

Bruniec Arenosols
Wskaźnik Dostępności Edukacyjnej
Analiza podręczników
Edukacja gleboznawcza
Świadomość gleboznawcza w społeczeństwie

Streszczenie

Gleby rdzawe zajmują około 15% terytorium Polski i są jednym z najważniejszych typów gleb wykorzystywanych w gospodarce leśnej. Są one powszechnie znane w środowisku gleboznawców, jednakże poziom wiedzy na ich temat wśród społeczeństwa (uczniów, studentów i osób nie związanych z naukami o glebie) jest zdecydowanie niewystarczający. Czy wybór gleby rdzawej na Glebę Roku 2021 jest szansą na zmianę w tym obszarze? Celem niniejszego opracowania jest zdiagnozowanie poziomu dostępności informacji o glebach rdzawych na etapie edukacji w szkołach średnich oraz określenie stanu wiedzy o tych glebach w społeczeństwie. Zastosowano trzy główne metody badawcze: analizę podręczników geografii, analizę źródeł internetowych oraz metodę ankietową. Wyniki analiz wskazały, że informacje o glebach rdzawych w niewielkim stopniu są prezentowane w podręcznikach szkolnych. Spośród 17 analizowanych stron internetowych na 8 nie ma żadnych informacji o tych glebach. Opracowany na potrzeby prezentowanych badań Wskaźnik Dostępności Edukacyjnej informacji na temat gleb rdzawych jest jednym z dwóch najniższych spośród wszystkich analizowanych jednostek glebowych. Respondenci nisko oceniali swoją znajomość gleb rdzawych, ale wyrażali chęć poszerzenia swojej wiedzy w tym zakresie. Niewystarczający poziom informacji na temat gleb rdzawych nie ogranicza ich rozpoznawalności. Respondenci nie mieli problemu ze wskazaniem gleby rdzawej na podstawie zdjęcia, ani też z określeniem właściwej liczby poziomów genetycznych. Rok Gleby Rdzawej stwarza doskonałą okazję do zaoferowania szerszej wiedzy o tych glebach młodym odbiorcom poprzez akcje promocyjne i zajęcia terenowe. Lekcje terenowe mogą łączyć edukację gleboznawczą z zagadnieniami ekologicznymi. Wiedza dotycząca gleb rdzawych, jako element edukacji formalnej i nieformalnej, może przyczynić się do wzrostu świadomości ekologicznej, szczególnie w odniesieniu do gleb powszechnie występujących i ważnych dla lokalnego środowiska.