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Editorial

Dear Readers,

I am happy to announce that finally we have completed hard work on the English issue of the quarterly Biological and Environmental Education. Now it is ready to be handed off to our readers. In this issue, you will find articles assigned to either SCIENCE section or SCHOOL section.

In the present issue, we offer you wide variety of articles aligned in growing size of the main characters of each article. SCIENCE section begins with *Bacterial species – from theory to practice*. You would be surprised if you are used to the concept of biological species known for animals or plants. How it can be different in the world of bacteria? The answer is in the abovementioned article. If you prefer a bit larger organisms, you should get familiar with following articles: *Moulds – friends or enemies?* and *Dung beetles and their role in the nature*. The SCIENCE section closes with *Red fox (Vulpes vulpes) as a synurbic species and its role in the spread of the Echinococcus multilocularis tapeworm*.

The SCHOOL section contains three articles: *Importance of digital spatial data in environmental education*, *Knowledge about local natural monuments – ignorance or flaws of the education system?* and *Elements of Health Education in Science Coursebooks*. The last article is a comprehensive review on health education in Poland. Especially if you reached our quarterly from abroad, you are strongly encouraged to read articles published in this section as they present current problems and hopes of education in our country.

I would like to thank Polish Ministry of Science and Higher Education for financial support upon English translation of all texts published in this issue. Dedicated work of our colleagues from Institute of Educational Research, Karolina Kwiatosz and Marcin Trepczyński, is also greatly acknowledged.

Happy Holidays and enjoy English issue of Biological and Environmental Education.

Kind regards,

Takao Ishikawa

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Ministerstwo Nauki i Szkolnictwa Wyższego

Bacterial species – from theory to practice

Marek Bartoszewicz

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Summary:

Although the Mayr's definition of species is commonly accepted for eukaryotic organisms, bacteria do not meet those established criteria. Thus, a special approach is necessary to elaborate the definition resistant to such limitations as for example the lack of sexual reproduction or horizontal gene transfers. One of the most problematic taxa in microbiology is the Bacillus cereus group composed of several closely related bacteria. Thus, on the basis of this model, doubts concerning bacterial taxonomy are discussed in the light of actual, molecular data.

Key words: taxonomy, phylogeny, species, bacteria

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Introduction

The definition of biological species includes the basic unit of biological classification and also a rank defined by Ernst Mayr as a group of individuals that can produce fertile offspring, usually by sexual reproduction and are reproductively isolated from other populations (Mayr, 1942). Next, members of the same species occupy similar environmental niches and have the same phylogenetic origin (Mayr, 1982). While this concept is accepted, it may be problematic in case of numerous organisms. Problems may be linked to interspecific hybridization, presence of chromosomal races like among common shrews (Fedyk and Chetnicki, 2007; Ratkiewicz et al., 2002) or ring species observed among birds. Next exceptions can be seen when organisms reproduce asexually (by mitosis) or when parthenogenesis occurs. Moreover, in paleontology it is rather impossible to verify sexual reproduction of extinct life-forms.

Unfortunately, this definition is also inappropriate in bacteriology. Bacterial diversity is much higher than observed among other organisms, probably due to common occurrence in soil, air, water and food, their fast multiplication (time of generation under optimal conditions often does not exceed 30 minutes) and weak correctional activities of their polymerases (Cohan, 2002a; 2002b). Moreover, haploid genome and intensive horizontal gene transfer complicate their diversity even more. Next, still bacterial diversity is only particularly explored and only a small part of bacterial species has been already described (Cohan and Perry, 2007). In some circumstances, specific requirements (e.g. nutrients, media composition, and pressure) lead to problems with cultivation of bacteria. However pure bacterial culture is necessary in order to describe a new species (Małek et al., 2005). The scope of this paper is to describe the actual knowledge focused on the concept of bacterial species and to discuss important problems with cohesive taxonomy concept of microbes by the aid of interesting examples.

From history to the present days

Bacteria were initially discovered by Antonie van Leeuwenhoek (1632-1723) in late seventeenth century, but the role of these microscopic forms remained unknown. Finally, Louis Pasteur demonstrated microbiological fermentation and suggested that microbes may cause diseases of mammals, including humans. However, the milestone in bacterial taxonomy was reached by Robert Koch and his procedure for isolation of pure bacterial cultures using solid media for bacterial growth. Using recent findings, a basic and artificial taxonomy focused especially morphology of cells and colonies, as well as bacterial properties and virulence was constructed. Next, biochemical activity gained importance, usually followed by numerical analyses. Nevertheless, the discovery of molecular methods and elaboration of several DNA-based techniques has allowed for a real progress in bacterial taxonomy (Maughan and van der Auwera, 2011). In this approach, total DNA-DNA hybridization level (depicting an overall similarity between compared genomes) and G+C content (measuring a proportion of guanine and cytosine nucleotides in total DNA) were assessed (Małek et al., 2005). However, these techniques have also several limitations. For example, similar values of G+C content are often observed for distinct taxa, while DNA-DNA hybridization is expensive and time-consuming, tricky method. Nowadays, nucleotide sequencing techniques including analysis of ribosomal RNA organized in *rrn* operon (Fig. 1) or sequencing of so-called *housekeeping genes* (multi-locus sequence typing) enable the development of natural system reflecting the phylogeny and evolutionary traits of bacteria domain (Rasko et al., 2005; Raymond et al., 2010). Unfortunately, even rRNA analyzes are not the perfect solution. Its relatively conservative characteristics prevents from the detection of subtle differences between closely related species, which may exhibit identical sequences of the 16S rRNA gene (Bartoszewicz et al., 2009). Thus, the concept of bacterial species is still widely discussed and requires further investigations to develop universal genetic markers and

optimal, commonly accepted phenotypic features. At present, hopes are associated with techniques based on the whole-genome analyzes (Liu et al., 2015). Digital DNA-DNA hybridization provides more accurate data than its spectrophotometric variant, while using of the whole-genome sequence-based Genome BLAST Distance Phylogeny (GBDP) approach leads to the description of new taxa among groups of already known strains (Meier-Kolthoff et al., 2013).

What do we call 'bacterial species'?

The definition of biological species was developed for organisms with sexual reproduction and it works well in the case of numerous plants or animals. According to its assumptions, sexual isolation leads to the speciation process because of the lack of the gene flow between distinct populations. Unfortunately, these guidelines proposed by Ernst Mayr, cannot be directly applied to the microorganisms. Thus, new problems arise. First of all, there must be a discreet force that binds bacteria belonging to one species and supports their differentiation from other bacteria. We can hypothesize that natural selection plays that role. According to the basics of theory of evolution, it favors adaptive mutations increasing microbial fitness and eliminates less adapted bacteria. Apart from a directional, stabilizing and disruptive selection, often described for eukaryotic organisms, bacteria are also affected by similar environmental pressure. Among others it turns out that purifying selection, leading to the clonal structure of microbial populations was described. Extreme cases of antibiotic resistance, like *Klebsiella pneumonia* New Delhi (Khan et al., 2017) or narrow specialization of pathogens, like *B. anthracis*, an anthrax agent (Kolsto et al., 2009) may have huge role in adaptation to host or 'hospital environment'. Finally, different species should evolve independently, however it is not clear whether their evolution is mostly supported by their horizontal gene transfer or environmental pressure (Wiedenbeck and Cohan, 2011).

Although there is no agreement as to the coherent definition of bacterial species, the most widely accepted definition assumes that one species includes a group of closely related bacteria, with common ancestor, having at least 97% identity of the 16S rRNA gene sequence and not less than 70% similarity of DNA-DNA hybridization. Moreover isolates from one species must be distinguishable from other species on the basis of one or more phenotypic properties (Małek et al., 2005), e.g. motility, toxicity or adaptation to grow at cold (psychrotolerance).

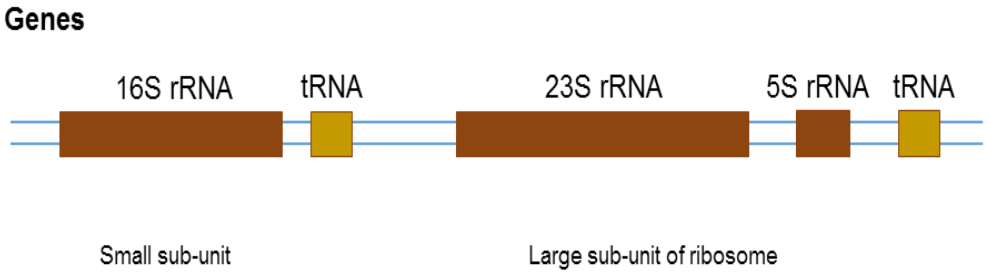

Fig. 1. Organization of ribosomal RNA operon (*rrn*) in prokaryotes

Nucleotide sequence of 16S rRNA (corresponding to ribosomal small subunit) is composed of numerous hypervariant regions (suitable for the assessment of phylogenetic relationships of closely related bacteria) and conservative regions (optimal for investigations of bacteria pertaining into one genus or family). 23S and 5S rRNA necessary for a large sub-unit are also objects of molecular genotyping.

Universal taxonomy – 'Holy Grail' for microbiologists

The microspace of bacteria is extremely differentiated and distinct apart from the world of eukaryotes, however both of them interpenetrate each other. Nevertheless, a question arises if the definition of bacterial species fits to all microorganisms and if not, what are the doubts and problems for further consideration. This can be well illustrated by the use of a suitable and complex microbiological model. Here an example of *Bacillus cereus sensu lato* group of bacteria appears useful, as its taxonomy is being discussed for several years (Jensen et al., 2003). This group is composed of several closely related species, but mainly of *B. cereus* (food poisoning causative factor), *B. thuringiensis* (used for production of biopesticides) and *B. anthracis,* an anthrax causative factor (Bartoszewicz et al., 2006; Moayeri et al., 2015). Not all of these bacilli can be morphologically distinguished from each other, e.g. under microscopy. However, according to the definition of bacterial species, there must be some features enabling their identification. Thus *B. anthracis* differs by forming characteristic poly-D-glutamic capsule that prevents this organism from phagocytosis by the neutrophils or macrophages of the host (Mock and Fouet, 2001). Next, it forms two different toxins, a lethal toxin and edema factor, both involved in the development of anthrax symptoms. What is more, *B. anthracis* is non-motile and suscep-

tible to penicillin, an antibiotic produced by *Penicillum* sp. In turn, *B. thuringiensis* does not show any virulence to vertebrates. However, during sporulation (a process of forming dormant spores, structures highly resistant to environmental stresses), this bacterium produces crystalline inclusions composed of delta-proteins, often called Cry toxins (Święcicka, 2008). Crystals can be visualized by a specific staining or by the use of phase-contrast microscopy. Next example is *B. cereus,* which is involved in emetic and diarrheal syndromes and occasional infections. It is also devoid of parasporal inclusions and it is believed to be incapable to synthesize anthrax toxins, however it forms its own toxic peptides active against epithelial cells of the intestines (Stenforns Arnesen et al., 2008). In theory, identification of each particular species should be easy. In fact, there are some important problems.

First of them is linked to complex genetic structure of these bacteria. Initial studies using different molecular techniques for the genetic fingerprinting including RAPD (random amplification of polymorphic DNA) or PFGE (pulse-field gel electrophoresis) gave evidences on high level of genetic polymorphism, but they failed in case of establishing species-specific markers (Kaminska et al., 2015). A protein-depended approach called multi-locus enzyme electrophoresis (MLEE) also did not bring new insight into the taxonomy, however all these techniques rather suggested that we deal with one complex species (Helgason et al., 2000). Next, sequencing of 16S rRNA revealed 99,1-100% identity between strains from different taxa (Bartoszewicz et al, 2009), what also suggests one species according to present bacterial species definition. From the other hand, classic and digital DNA-DNA hybridization, a golden standard in taxonomy, often showed less than 70% similarity (Liu et al., 2015). Values below this cutoff strongly support presence of distinct individual species. Finally, an approach of sequencing several housekeeping genes (technique named MLST, multi-locus sequence typing) proved that phylogenetic structure of *B. cereus sensu lato* corresponds better to their ecological properties than to taxonomic affiliation (Święcicka et al., 2013; Drewnowska and Święcicka 2013; Kamińska et al., 2015). For example, cold adapted bacteria (*syn*. psychrotolerant) formed independent clade, as well as human pathogens related to *B. anthracis*. All these recent findings are in fact good arguments for the conception of distinct ecological types (ecotypes), which may be the answer for the problem with clear bacterial taxonomy (Święcicka et al., 2013).

Another problem is linked to horizontal gene transfer (HGT), a quite common process resulting in recombination of genetic information. Naturally, its rate among different microbes varies significantly from low (extremophiles, like cyanobacterium *Microcystis* spp.) to high values (e.g. *Neisseria meningitidis,* causative factor for meningitis and sepsis in children). HGT includes three different mechanisms: (a) transformation (obtaining DNA from the environment), (b) transduction (when a bacteriophage is a vector that transmits DNA), and finally (c) conjugation (parasexual process, in which two bacteria of different types join altogether and a donor provides, while recipient receives genetic information). Especially the last one appears to be quite common among *B. cereus* and related bacilli, as showed by Clonal Frame statistical analyzes of homologues recombination to mutation ratio (Vos, Didelot, 2009; Kaminska et al., 2015).

Why conjugation is mentioned as a problem for a concise taxonomic concept of bacteria? First of all, we need to realize that species-characteristic features must be stable and they cannot be transferred to other species or lost during proliferation. In this context, for example, the biosynthesis of Cry proteins which depends on specific, large plasmids containing *cry* genes is problematic. Numerous extrachromosomal elements with different types of *cry* genes were already described (Patel et al., 2013). However, if *B. thuringiensis* multiplicates, we cannot exclude the loss of a plasmid, even the plasmid with *cry* genes. This would result in the inability to synthesize Cry toxins. In this case, *B. thuringiensis* would

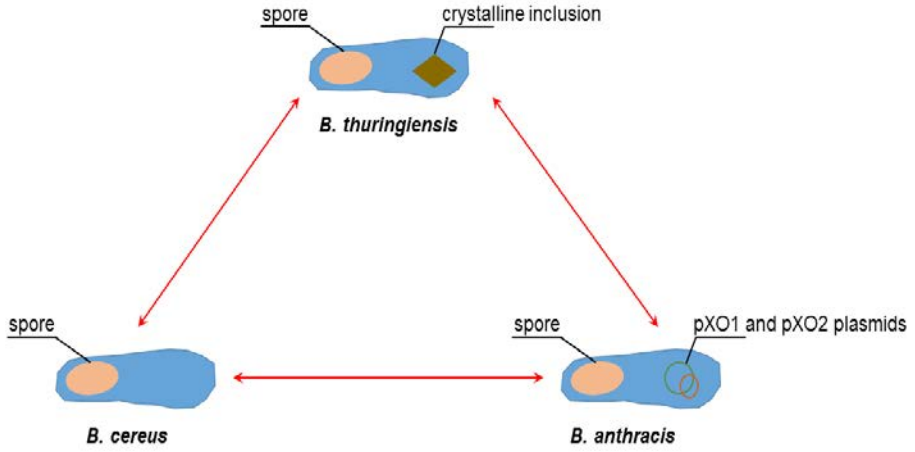

Fig. 2. Horizontal gene transfer among *B. cereus sensu lato* bacteria

Conjugation occurs in different matrices including soil, biofilms or food products. By the transfer of the genes responsible for the presence of species-specific features, bacteria may obtain properties of other taxa becoming indistinguishable from them.

become phenotypically and genotypically indistinguishable from its relative, *B. cereus* (both bacteria show also more than 99% identity of 16S rRNA gene sequence and >70% of similarity in DNA-DNA hybridization). Moreover, if *B. cereus* receives *B. thuringiensis* typical plasmid, it will become *B. thuringiensis*-like bacterium. Like above, both important properties of *B. anthracis*, its toxicity and capsule formation, also require suitable plasmids, in this case pXO1 – for toxins and pXO2 – for capsule (Mock and Fouet, 2001; Cote and Welkos, 2015). Even if their transfer is not common in the natural habitats, several isolates of *B. cereus* provoking symptoms of inhalational anthrax were described. So, the genetic exchange of extrachromosomal elements could cause additional confusion and complications of *B. cereus sensu lato* genetic structure (Modrie et al., 2010). This is illustrated in Fig. 2. It must be mentioned that conjugation is possible between closely related species, however recent studies suggest also HGT events between phylogenetically distant microbes.

Conclusions and ideas for the future

Apart from serious complications, bacterial taxonomy is not a hopeless case. From the practical point of view, the distinguishing of particular species and elaboration of precise criteria for their identification are of the top interest. Fast and efficient identification of pathogens in medicine and veterinary or food production requires suitable procedures (Bartoszewicz et al., 2008; Obrębska et al., 2008). Complicated taxonomy, different in case of distinct bacteria may lead to the conclusions, that the best solution is an ecological approach. It is based on relationships between microbe and host or environment. For laboratory diagnostics it is not necessary to establish whether bacterium is named *B. cereus* or *B. anthracis*, but if it is capable of causing a disease. To assess it, we can perform a PCR test targeted for the *pag*, *cya* or *lef* genes encoding anthrax toxins. Moreover, immunological tests (e.g. enzyme-linked immunosorbent assay called ELISA or immunochromatographic tests) may be used for the detection of protein toxins. This idea, naturally, might be very useful not only regarding *B. cereus sensu lato*. Staphylococci are divided into coagulase-positive (CPS) and coagulase-negative strains (CNS), both with variable virulence. Next, they are often differentiated on the basis their resistance to antibiotics, e.g. MRSA (methicillin-resistant *Staphylococcus aureus*) or MSSA (methicillin-susceptible *S. aureus*). This brings clear message for the potential therapy. So in different branches if industry and medicine, test should be focused on interesting properties that might be present among examined bacteria. And what we should do with groups of problematic bacteria, like *B. cereus sensu lato*? In 2002, Hugenoltz proposed a concept of bacterial groups composed of closely related bacteria with common origin but doubtful taxonomy. According to this suggestion, *B. cereus sensu lato* should treated as such bacterial group (a rank that has not already been officially accepted in systematics and taxonomy) because of their common ancestry. However partially limited HGT, ecological isolation and different features favored by natural selection may lead to speciation in the future. Thus a situation observed for *B. cereus sensu lato* may be a transient state before the formation of valid species.

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Moulds – friends or enemies?

Olga Aleksandra Paramonova, Adam Tylicki

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Summary:

Moulds are common in our habitat and play significant role in the economy and household. The aim of the article is the indication of selected benefits and threats of moulds present in human environment. The main benefits are: antibiotic synthesis (e.g β-lactam antibiotics production), moulds application in food industry (e.g. mouldy cheese production) and industrial biotechnology (e.g. organic acids synthesis). Threats which are related with moulds presence in our environment are diseases of respiratory system, skin as well as allergies and also possibility of food contamination by mycotoxins synthesized by moulds which can cause animal and people poisoning. The main factors which increase exposure of people to adverse effects of moulds are high moisture, inefficient room ventilation and incorrect storage of resources for food production. Taking care of living quarters technical condition and appropriate control of quality and food storage conditions as well as raw materials for its production, we can reduce undesirable moulds effects.

Keywords: antibiotics, fungal infections, organic acids, mycotoxins, moldy cheese

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1. Introduction

Moulds are saprobionts capable of colonizing almost every environment. They are mostly found in the soil, rarely in fresh water and exceptionally in saltwater. High metabolic flexibility and limited need for growth and development, allow them to colonize ecological niches poor in nutrients necessary for the development of other microorganisms, such as: plastics, painted and plastered walls, wood or paper surface (Wiszniewska et al., 2004; Żukiewicz-Sobczak et al., 2012). On the other hand, mould – as chemoorganotrophic organisms – are eager to use rich organic substrates such as remnants of other organisms, as well as processed food or raw materials for its production, and our body. Filamentous fungi are facultative anaerobic organisms, so they grow best on all kinds of surfaces that provide air access, organic carbon sources and essential minerals, although absence of oxygen doesn't destroy the mycelium. High humidity of the substrate and air are the optimum conditions for the growth of these fungi, however many species, such as the xerophyll species of the *Aspergillus* and *Penicillium* genera, can survive under very dry conditions (Wiszniewska et al., 2004).

Fungus systematics is ununiformed and constantly modified according to new data on their phylogeny and kinship collected. According to the taxonomic rank by Schübler et al. (2001), moulds belong to the Fungi, represented by the following types (divisions): *Ascomycota*, *Basidiomycota*, *Glomeromycota* and *Zygomycota*. Many species of mould were previously classified into an artificially formed group – *Fungi imperfecti* or *Deuteromycota*. It is now known that *Fungi imperfecti* are mainly conidia stages, anamorphs of *Ascomycota*, rarely of *Basidiomycota* (Grzywacz 2015). Therefore, in new classifications, the taxon of *Fungi imperfecti* is not classified (Schüßler et al., 2001, Hibbett et al. 2007).

An important aspect to consider for fungi taxonomy is their organs of reproduction. Fungi that reproduce asexually (through mitotic divisions) produce mitospores (e.g. conidia spores). These spores are produced in large quantities, mostly at the tips of the mycelium. Asexual production of spores is often due to the extreme specialization of the fungi, because genetic studies show that they possess genes that regulate sexual reproduction (Muszewska 2014). As a result of the meiosis, fungi produce haploid spores – meiospores, which are a product of sexual processes (e.g. gametogenesis, zygogenesis and somatogamy).

Molds generally reproduce asexually through mitospores (endospores, conidia, arthrospores). *Zygomycota* (e.g. *Mucor, Rhizopus*) produce endospores (endogenous mitospores) in the sporangium. The conidia spores formed exogenously at the tips of conidiophores (aerial hyphae) are often formed in *Ascomycetes* (e.g. *Aspergillus*, *Penicillium*). *Geotrichum candidum* (*Ascomycota*) form single-celled arthrospores (oidia) as a result of fragmentation of the mycelium hyphae. Fungi of the *Glomeromycota* often produce so-called glomoid spores on cylindrical or funnel-like spore-forming hyphae (Schüßler et al., 2001).

Only some mould species reproduce sexually, where they produce meiospores as a result of the meiosis. Because of the way of meiospores formation they are divided into: *Ascomycota*, *Basidiomycota* and *Zygomycota*.

Moulds form a mycelium composed of aseptate hyphae (e.g. *Zygomycota*), or septate hyphae (*Ascomycota*, and *Basidiomycota*). Moulds produce huge amounts of spores that travel long distances in air and water, there-

fore in extreme cases spore concentrations in contaminated rooms can exceed $1\times10^5/m^3$ of air. These fungi are also capable of producing mycotoxins and antibiotics, thanks to which they can compete with other microorganisms that occupy the same ecological niche (Wiszniewska et al., 2004).

Moulds are, therefore, extremely common saprobions to which we exposed all the time. Looking at the biology of these fungi, one can argue that they greatly affect the environment they occupy and the organisms that coexist with them, including humans. Moulds can affect other organisms directly, growing on them and using them as a source of food or indirectly through spores and metabolites – antibiotics and toxins. On the other hand, the same abilities of moulds metabolism to metabolize various organic compounds can be used in numerous biotechnological processes.

The purpose of this work is to indicate the benefits and risks of the common presence of mould in the human environment and to familiarize the reader with examples of such influence.

2. Positive aspects of the presence of mould in the human environment

People have been using the properties of moulds in their economy for a long time. They have particularly widespread applications in food biotechnology: in blue cheese production (*Penicillium* species) and meats with mould rind (*Penicilium nalgiovense*). The best known oriental foods for which moulds are used are: soy sauce – shoyu, the production of which requires lactic acid bacteria and yeast, but also *Aspergillus oryzae* or *A. soyae* cultures; soybean paste (miso, yang, tao chieo – depending on the country of origin) obtained from steamed soybeans with *A. oryzae* and *Rhizopus oligosporus*; tempech obtained from skimmed soybeans or legumes with *Rhizopus* or *Mucor* moulds. In Africa, fermented foods obtained from cassava (gari) or maize (ogi) that are a significant part of the diet, are produced with the use of bacteria, yeasts and moulds (*Geotrichum*, *Fusarium*, *Penicillium*, *Aspergillus*).

The properties of moulds have been applied in the processes of biotransformation of organic compounds (mainly acids) and enzyme production (lipases, proteases, amylolytic, cellulolytic and pectinolytic enzymes) used in various technological processes – mainly in the food industry. In addition, moulds are of great importance in medicine as a source of antibiotics. These compounds help in effectively fighting bacterial infections which used to be extremely difficult to treat before antibiotics were discovered. Also lovastatin, which is obtained from *Aspergillus terreus* and *Monascus ruber*, has been used in medicine to reduce blood cholesterol concentration.

Moulds are also used as plant protection products (*Beauveria bassiana, B. brongniartii, Entomophthora grylii, Metarrhizium anisopliae, Paecilomyces fumosoroseus, Verticillium lecanii*). Preparations containing spores of these fungi (e.g. Preferal, Boverin, Mycotal) are sprayed over crops mainly for the purpose of eradicating greenhouse pests such as aphids, mites or spider mites (Żakowska and Piotrowska, 2013).

Below you will find some aspects of mould use of in the economy.

2.1. Moulds as a source of antibiotics

Moulds play an important role in medicine as a source of antibiotics. Species from the genus *Penicillium* and *Aspergillus* produce β-lactam antibiotics, among which is the first antibiotic used in medicine, namely benzylpenicillin (penicillin G). It was discovered in Fleming's laboratory in the *Penicillium notatum* and *P. chrysogenum* cultures in 1929. Phenylacetate

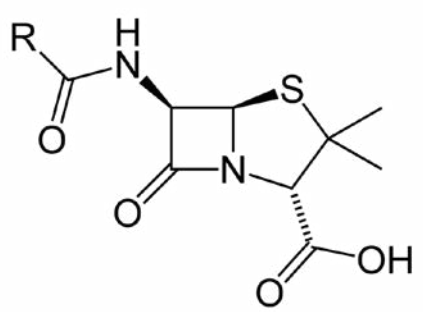


Figure 1. General structural formula of penicillin

Source: Wikimedia Commons.

is added to the medium as a precursor in penicillin G production, while the addition of phenoxyacetate leads to synthesis of penicillin V. The penicillin structure (Figure 1) is based on 6-aminopenicillanic acid, composed of cysteine and valine combined in a double β-lactamotiazolidine ring (Mieszkowski et al., 2011).

Penicillins as well as cephalosporins, cefamycin, carbapenems and monobactams are included in the group of β-lactam antibiotics. All these antibiotics have a β-lactam ring that is linked to another 5- or 6-membered ring (except for monobactams). In addition, each antibiotic in this group has a characteristic side chain (R in Figure 1) which is attached to the β-lactam ring. These antibiotics may also have other side chains, with a cyclic system adjacent to the β-lactam ring. They are highly bactericidal to Gram-positive bacteria (e.g. Staphylococci, Streptococci, *Corynebacterium diphtheriae*) and Gram-negative bacteria (e.g. meningococci, *Treponema pallidum*). The principle of the cytotoxic effect of β-lactam antibiotics is the inhibition of the bacterial cell wall biosynthesis due to glycopeptide transpeptidase deactivation. This prevents the peptidoglycan subunits joining into the final form of the murein polymer. The glycopeptide transpeptidase binds the alanine of one peptidoglycan subunit with the pentaglycine

bridge of the second peptidoglycan subunit. Penicillin, through the β-lactam ring that is reminiscent of the peptide bond between the alanine residues of the peptidoglycan subunit, is incorporated into the active center of the enzyme causing inhibiting of its activity. The serine residue (OH group) in the active centre of the glycopeptide transpeptidase is bound to the carbonyl group of the penicillin β-lactam ring. The limitation of the murein synthesis inhibits the growth and multiplication of bacteria, resulting in their death (Pałczyński and Jakubowski, 1996; Mieszkowski et al., 2011).

In addition to penicillins and cephalosporins, other antibiotics are also obtained from mould cultures (Chmiel 2013), for example fusidic acid (*Fusidium coccineum*, *Paeciliomyces variotii*), griseofulvin (*Penicillium griseofulvum*), cyclosporin (*Tolypocladium niveum*).

2.2. Use of moulds in cheese production

Moulds play an important role in the production of cheeses with mould growth and overgrowth. Freeze-dried or liquid mould spores are used in the cheese industry to obtain products of exceptional taste and aroma (Kołakowski et al., 2013).

Mould gives cheeses its characteristic (mainly white) look, protects the cheese against spoilage by undesirable mould growth (e.g. *Mucor*), and as a result of the lactic fermentation, it increases the acidity of the cheese. Milk, rennet, salt and micro-organisms are used in the production of blue cheese. The cheese microbiota can be divided into two main groups: starter microbiota (basic and auxiliary) and non-starter microbiota. Moulds along with yeasts, synovial and probiotic microorganisms make up start and auxiliary microbiotics. Spores of noble moulds are most often added to milk in concentrations of about 100 spores per ml of milk (Kolakowski et al., 2013).

The main types of blue cheeses are Camembert and Brie (soft with mould growth), Crescenza and Munster (soft stabilized with mould growth) and Roquefort (with blue mould overgrowth). Different *Penicillium* species (Table 1) are used in the production of these cheeses. Studies conducted on more than 80 cheeses from the Marmara region in Turkey showed over 160 species of moulds in the cheeses studied. The most common were *Penicillium* species (over 50% of cheeses), less common were *Aspergillus* and *Mucor* (15% and 16%, respectively). 16% of the cheeses tested showed the presence of fungi from species other than the listed above (Erdogan et al., 2003). The diversity of moulds cultivated in cheese may indicate the potential for contamination of these products with mycotoxins. In studies conducted on cheeses commercially available in five Turkish cities, more than 50% of tested products contained a dangerous aflatoxin M in concentrations ranging from about 10 to over 700 ng/kg (Ozgoren and Seckin, 2016). By studying the toxin production of *Penicillium roqueforti* strains isolated from blue cheese, it was found that these species produced patulin, penicillinic acid, PR and roquefortin

Type of cheese	Cheese kind	Mould species
Soft with mould growth	Camembert Brie	*Penicillium camemberti* *Penicillium candidum*
Soft stabilized with mould growth	Crescenza Munster	*Penicillium camemberti* *Penicillium candidum*
With blue mould overgrowth	Roquefort	*Penicillium roqueforti*

Table 1. Selected types of blue cheeses with fungi most commonly used in their production (according to Kołakowski et al., 2013)

in varying amounts depending on the growth temperature. The fungi produced the least toxins at 5 ° C. With the increase of temperature, the ability to synthesize toxins also rise (Erdogan et al., 2003). The results of the study show that both the selection of mould strains for cheese production and the way they are stored are essential in reducing the risk of mycotoxin contamination of the product. This is of particular importance in view of the global annual production of rennet cheese (that also includes blue cheese) at about 84 million tons, which is a significant contributor to the overall production of dairy products (Cakmakci et al., 2012; et al., 2013; Dysz and Krasnowska, 2013).

2.3. Synthesis of organic acids

Filamentous fungi are capable of producing a variety of organic acids depending on the culture conditions and the organic carbon source used. These include lactic acid, fumaric acid, citric acid, oxalic acid and itaconic acid (Figure 2). Lactic acid is produced by specialized strains of *Rhizopus oryzae* that are capable of producing it in the pentose phosphate pathway, activated by lactic fermentation. In turn, fumaric acid, which is used predominantly in acidification of food and in the production of synthetic resins, is obtained in *Rhizopus nigricaus* cultures (Żakowska and Piotrowska, 2013). The production of citric acid is based on the use of one of three techniques: surface method, submerged method and on solid media. The surface method, which produces citric acid (as the main product) as well as oxalic acid as a by-product of the process (Figure 3), used molasses – a source of glucose, fructose and sucrose. After sterilization, the molasses medium is poured into the fermentation trays and placed in chambers with continuous air circulation and temperature control. When the temperature of the medium falls to 40 ° C, it is inoculated with *Aspergillus niger* spores. After 24 hours of

incubation, a thin mycelium appears, and its lower layer that adheres to the substrate initiates an intense synthesis of citric acid. This process takes 7-9 days at 30-34 ° C. After changing the culture conditions (pH = 7 and excess phosphorus) *Aspergillus niger* starts to induce the synthesis of oxaloacetal hydrolase, an enzyme that decomposes oxaloacetate to oxalic acid and acetic acid. With low pH and phosphorus deficiency, the main fungal metabolite product is citric acid. The highest yield of citric acid is achieved in the submerged method, which accounts for more than 80% of the world's production of this acid. In this process, unlike the surface method, the mycelium grows in the entire volume of the medium. Citric acid on solid substrates is synthesized from potato, sugar cane, beet pulp and other waste vegetable raw materials. This technology does not require special bioreactors and also *Aspergillus niger* cultures on solid media are able of tolerating high concentrations of metal ions (Żakowska and Piotrowska, 2013). Citric acid is widely used in the food (beverages, dairy products, sweets, jellies, jams, preservatives), metallurgy (metal cleaning), oil (fat and oil production) and pharmaceuticals industries (Soccol et al., 2006). It is worth mentioning that the global annual production of this acid is 1.4 million tons (Musiał and Rymowicz, 2009; Soccol et al., 2006; Swain et al., 2011; Kałuża and Sadowski, 2013).

Oxalic acid in industrial production is chemically synthesized. Currently, work on new routes of oxalic acid producing are carried out because of considerable amount of toxic waste generated as a result of chemical synthesis (Musiał and Rymowicz, 2009). A good example of such research is the attempt to use of rape cake, which is a waste material of oil production, for oxalic acid synthesis by *Aspergillus niger* on solid media. As a result of the experiment it was found, that on starch or sugar substrate *A. niger* mainly produced citric acid, whereas after converting the biotransformation material into rape cake, the fungus synthesized oxalic acid with high efficiency (Gąsiorek et al., 2007). Another method of obtaining oxalic acid, which may be an alternative to chemical synthesis, is the use of sunflower press cake in *A. niger* cultures on solid media. It was found, that when using this raw material, oxalic acid is the only organic acid produced with a maximum yield of about 100 grams per kilogram of medium. In addition, under these conditions, *A. niger* additionally produces significant amounts of cellulo- and xylanolitic enzymes used in various industrial processes (Gąsiorek et al., 2013). The above mentioned examples can be a good way of utilising waste after vegetable oil production to obtain oxalic acid.

Nowadays, itaconic acid also attracts broad interest. The production of this acid is based on cultivating *Aspergillus terreus* or *A. itaconicus* through submerged or surface methods, where glucose or sucrose are used as

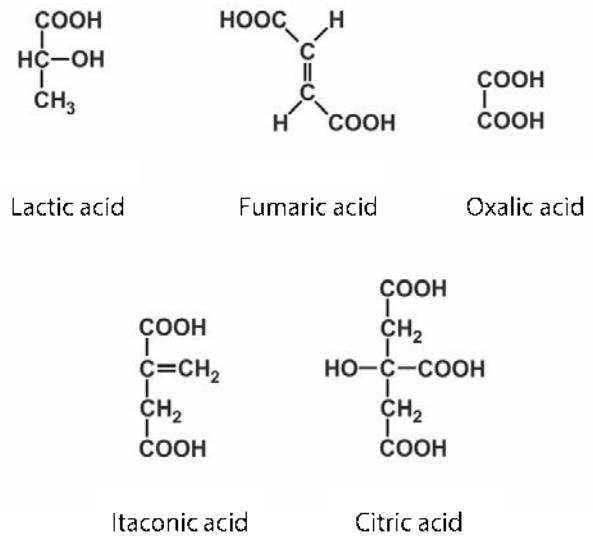


Figure 2. Chemical formulas of selected organic acids synthesized by mould

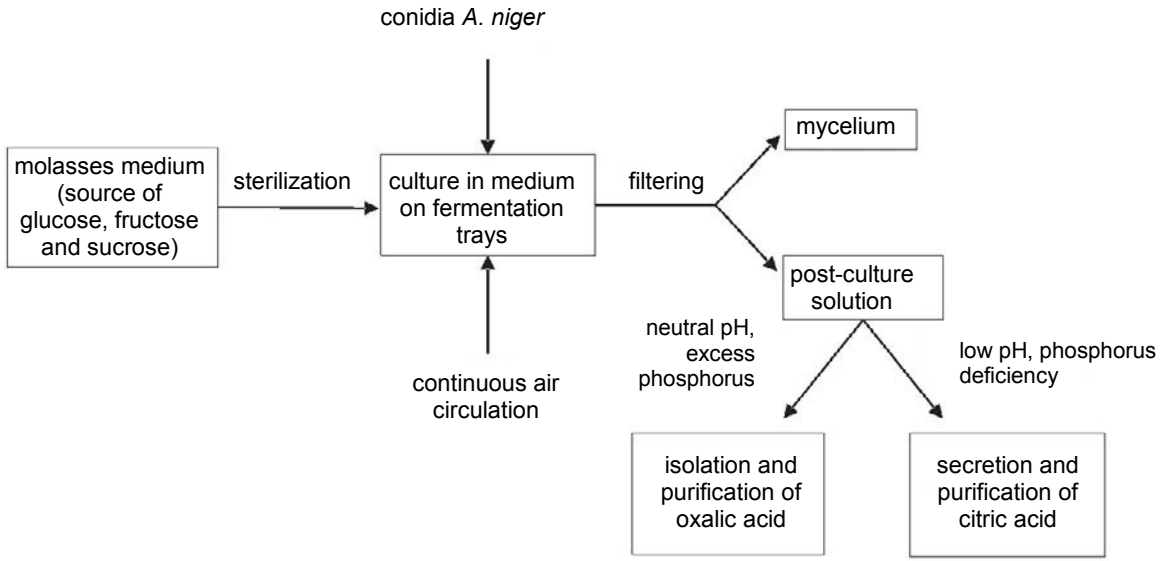


Figure 3. Production of citric acid using Aspergillus niger though surface culture method (Swain et al., 2011)

the carbon source. Itaconic acid, thanks to its ability to polymerize and improve the adhesive properties of various products, is used in industrial resin synthesis, biodegradable hydrophilic polymers, emulsion paints, polyesters, protective coatings and in the textile and paper industries, with an annual production of about 15,000 tons (Musiał, Rymowicz and Kautola, 2009; Żakowska and Piotrowska, 2013). Currently, we are looking for more possibilities in using other types of fungi (e.g. *A. flavus*) and alternative sources of organic carbon (e.g. corn starch hydrolyzate) to improve the yield of itaconic acid production (Wei et al., 2013, Sudarkodi et al. 2012).

3. Negative impact of moulds on human life

Even though, the benefits of using the properties of filamentous fungi are undeniable, one must also be aware of the serious risks to humans and animals from excessive contact with certain species of these organisms and their metabolites. Respiratory and skin problems, as well as poisoning and cancer caused by mycotoxins are particularly dangerous for humans.

3.1. Moulds in residential spaces

The first documented mention of the dangerous effects of fungi on human health, in buildings appeared in the nineteenth century, when the presence of *Penicillium*, *Cladosporium* and *Mucor* genus was confirmed in residential buildings in Copenhagen (cited in Żukiewicz-Sobczak et al., 2012). Structural elements of fungi (spores, hypha) may be the formation focus of the colony. They are considered as an important component of bioaerosols and their concentrations are referred to as colony-forming units (CFUs) per m^3 of air. The presence of moulds in indoor spaces is considered to be an important contamination factor (Wiejak, 2011; Schweer et al., 2016). The following species whose spores can cause harmful health effects, are especially important: *Stachybotrys chartarum, Cladosporium sphaerospermum, C. cladosporoides*, *C. herbarum* and fungi of the *Aspergillus*, *Penicillium*, *Fusarium*, *Trichoderma* and *Mucor* genera. Spores of these fungi can range from about 3-5 µm (*Aspergillus fumigatus*) to over 20 µm (*Epiccocum nigrum*) and can merge into larger aggregates, settling on different surfaces or remaining in the air (particles up to 5 µm) for a long time, covering significant distances (Mohr, 2002; Stetzenbach et al., 2004; Bonetta et al., 2010). High humidity, along with availability of oxygen and organic substances are the main factors for mould expansion. Excessive moisture, a factor promoting mould growth, is mostly caused by improper ventilation of the premises, lack of adequate insulation of foundations, ceilings and walls, inadequate maintenance of the plumbing system as well as structural defects of the roof covering. In the case of fungi, the outside air is the significant source of room contamination. Particularly highest concentrations of fungal spores are recorded in the summer (1000 to 4000 CFU / m^3), spore numbers in the air are about 10 times lower in spring and winter (Wiejak, 2011). Comparison of indoor and outdoor fungal aerosol concentrations shows that there is even 2 times less spores indoors than outdoors. Different results are obtained by measuring the concentration of bacterial aerosol (Lis et al., 1997). Organic materials such as wood, paints, adhesives and wallpaper which are a reservoir of organic compounds and water, serve as a favourable environment for mould development (Straus, 2009; Żukiewicz-Sobczak et al., 2012). Estimates of air pollution by spores of fungi are presented in Table 2. It should be noted that even in homes without a noticeable mould problem, there is a small concentration of fungal spores (60 CFU / m^3 air), whereas in moulded rooms it can reach a concentration as high as 17,000 CFU / m^3 of air (Pastuszka et al., 2000). Aside from living spaces, the risk associated with the presence of moulds applies to workplaces. Occupational groups particularly exposed to mould spores are office workers, librarians, farmers and food industry workers.

Country	The most common types	Concentration range (CFU / m^3)	
		Residential spaces	Office spaces
Poland	*Aspergillus, Candida, Cladosporium, Penicillium*	60 – 800	18 – 133
Italy	*Cladosporium, Penicillium*	100 – 300	220 – 860 >2000 <500
USA	*Alternaria, Aspergillus, Cladosporium, Penicillium*	1.8 – 2.4 (max. 33)[2]	

Table 2. Comparison of fungi bioaerosol content in living spaces and offices in different countries[1]

[1] – approximate data based on the following publications (Lis et al., 1997; Pastuszka et al., 2000; Sessa et al., 2002; Gooffit-Szymczak and Skowron, 2005; Bonetta et al., 2010)

[2] – data on hospital facilities (Hospenthal, Kwon-Chung and Bennett, 1998)

3.2. Diseases of the respiratory tract and skin caused by mould

The most common illnesses caused by mould include respiratory diseases and surface mycoses. Healthy people, who inhale mould spores should not experience any problems as long as spore concentrations in the air are low. Respiratory organs of healthy people contain self-cleaning mechanisms and adequate immune protection. However, prolonged inhalation of high spore doses (according to Finnish findings, the highest normal fungal aerosol concentration in sparsely populated areas should not exceed 500 CFU/m^3) may represent a serious threat (Reponen et al., 1992). Mould spores can

cause infectious diseases. Spores can attack the lungs of people with reduced immunity (e.g. AIDS patients or cancer patients) leading to lung colonization and the development of fungal hyphae. Bronchial asthma, allergic rhinitis and bronchial pneumonia are the main respiratory diseases caused by mould (Żukiewicz-Sobczak et al., 2012).

Bronchial asthma is a disease caused by an early type allergic reaction, which involves IgE antibodies, called reagins. The characteristic symptoms of this disease are bronchospasms and asthmatic coughs, most common at rest. The most common cause of this disease among the fungal origin factors, is Alternaria alternata spores (Żukiewicz-Sobczak et al., 2012).

Allergic rhinitis is a disease that causes inflammation of the mucous membranes and conjunctivitis in people with hypersensitivity. Characteristic symptoms are watery secretion, pruritus and sneezing (Wiszniewska et al., 2004).

Hypersensitivity to *Aspergillus fumigatus* can lead to allergic bronchopulmonary aspergillosis. It is an opportunistic infection, and the disease develops in 1-20% of people with asthma. Inhaled spores are not removed from the respiratory tract, resulting in the development of fungal colonies in the bronchial lumen. In infected individuals it causes periorbital pain and chronic bronchitis, what gradually leads to bronchial destruction and pulmonary fibrosis. The illness in its advanced form is difficult to cure and can lead to death. The limited amount of effective medicines is a serious problem in the treatment of aspergillosis. Good results are achieved by intensive amphotericin B treatment which causes the destruction of fungal cell membranes (Wiszniewska et al., 2004; Seyedmousavi et al., 2015).

Superficial mycoses is a separate group of diseases, which are caused by mould. This type of infection mainly occurs on the nail plate and the incidence ranges from a few to 50% of all cases of nail mycosis. Table 3 shows the results of a 3-year mycological studies, which covered 1059 people from Bydgoszcz. Based on the data it can be observed that in 2008 and 2009 more yeast-like fungi were isolated, whereas in 2010 the infections caused by moulds were predominant (Śpiewak, 1997, Kaczmarek and Brzezinski, 2012, Krzyściak and Talaga, 2015). Different species of moulds that belong to the *Aspergillus*, *Scopulariopsis* genera, and to the lesser extend to the *Alternaria* and *Chaetomium* genera were found during diagnosis of nail fungemia. In the course of an infection, the nail plate may stain yellow, yellowish, brownish or white. The disease may develops for a long time asymptomatically and is often recurrent. Untreated mycoses can lead to serious infections, in extreme cases ending with an amputation of the limb (Śpiewak, 1997, Kaczmarek and Brzezinski, 2012).

Pathogen group	Number of patients in each year			
	2008	2009	2010	Total 2008 – 2010
Moulds	128 37,2%	113 36,2%	177 64,8%	418 45%
Yeast fungus	159 46,2%	131 42%	27 9,9%	317 34,1
Dermatophytes	57 16,6%	68 21,8%	69 25,3%	194 20,9
Mould pathogens combined	344	312	273	929

Table 3. Groups of pathogenic fungi isolated from patients in 2008 – 2010 in Bydgoszcz (according to Kaczmarek and Brzezinski, 2012)

3.3. Mycotoxins

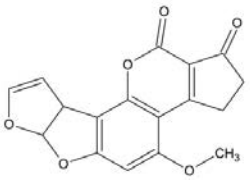
Humanity has been in contact with the toxic effects of secondary metabolites of moulds for centuries. An example of mycotoxins (aflatoxin) activity is the massive fall of turkeys on poultry farms in England in 1960. In 1988, In Malaysia, there were 13 deaths following the consumption of pasta contaminated with aflatoxins (Jarzynka et al., 2010). Currently, food contaminated with mould fungus leads to huge economic losses. According to the Food and Agriculture Organization (FAO) estimates, about 25% of the world's cereal grain, or up to 40% according to some estimates, is contaminated with at least one mycotoxin. Fungal metabolites are secreted externally into the medium as exotoxins or are collected in mycelium and conidia as endotoxins. Mycotoxins intake can lead to serious and even lethal poisoning in humans and animals (Jarzynka et al., 2010; Wróbel, 2014; Delgado et al., 2016).

Mycotoxins are poisonous metabolic products of moulds belonging mainly to the *Aspergillus*, *Penicillium*, *Fusarium* and *Stachybotrys* genera. Most are low molecular weight compounds (300 – 600 Da), for which the consumer cannot produce any antibodies. Most mycotoxins are resistant to physical agents. Currently, more than 500 mycotoxins have been chemically characterized, of which more than 20 may be present in food products and threaten the safety of potential consumers. Among them the most significant in food contamination are aflatoxins, ochratoxins, fumonisins and patulin (Grajewski 2006, Figure 4, Table 4).

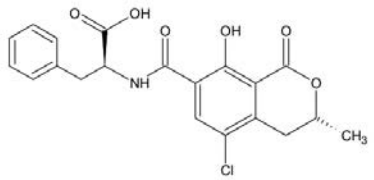
Aflatoxins are the most poisonous of mycotoxins. They are characterized by teratogenic effects, both in foetal and postnatal development, as well as carcinogenic effects, mainly affecting the liver. Nuts (pistachios, groundnut, Brazil nuts), spices (paprika, nutmeg) and dried fruits are important sources of aflatoxin contamination for humans. The most common aflatoxin is aflatoxin B1, mainly produced by *Aspergillus flavus*. Aflatoxin causes acute toxicity which can be quantified by the LD_{50} parameter. This is the amount of a toxin

Type of Mycotoxin	Effects of action	Mould species	Source of contamination
Aflatoxins	Mutagenic, teratogenic, cytotoxic, hepatocarcinogenic effects	*Aspergillus flavus Aspergillus parasiticus Aspergillus nomius*	Nuts, spices, dried fruits, dairy products
Ochratoxin A	Nephrotoxic, teratogenic, immunotoxic effects, altered cell cycle dynamics, increased frequency of mutations	*Aspergillus alutaceus Aspergillus niger Aspergillus carbonarius Aspergillus melleus Aspergillus ochraceus Penicillium purpurescens Penicillium commune Penicillium nordicum*	Cereals (mainly maize), animal source foods, wine, coffee, dried fruits, spices
Fumonisin	Neurotoxicity, disturbed lipid metabolism, gene expression modulation, oxidative stress	*Fusarium proliferatum Fusarium subglutinans Fusarium verticillioides*	Cereals, cereal products (mainly rice), beer, sorghum
Patulin	Hepatotoxic, carcinogenic, teratogenic, mutagenic effects	*Penicillium expansum Penicillium griseofulvum Aspergillus chevalieri Aspergillus clavatum Aspergillus terreus Byssochlamys fulva*	Fruit, fruit preserves

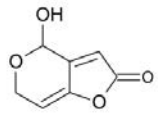
Table 4. Effects of mycotoxins, their source and mould that produce them (Creppy, 2002, Wróbel, 2014)



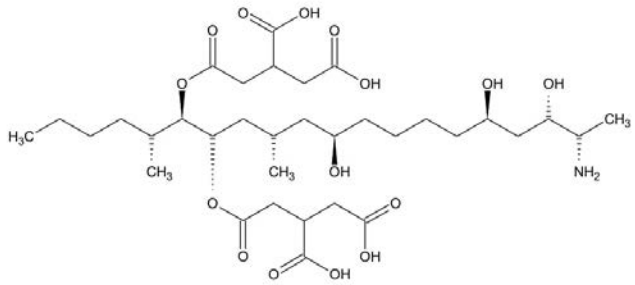
Aflatoxin B1



Ochratoxin A



Patulin



Fumonisin B1

Figure 4. Structural formula of selected mycotoxins

that causes death in half of the population of the tested animals. Table 5 presents the LD_{50} levels of aflatoxin B1 for exeplary lab animals. As indicated by the data, the aflatoxin B1 toxicity depends on the species and the sex of the animal (Serpuk, 2002; Wróbel, 2014).

Species	[1]LD_{50} (mg / kg of body weight)
Domestic rabbit *Oryctolagus cuniculus f. Domesticus*	0.3
Domestic cat *Felis catus*	0.55
Domestic pig *Sus scrofa f. Domestica*	0.62
Domestic sheep *Ovis aries*	1.0
Guinea pig *Cavia porcellus*	1.4
Black rat (male) *Rattus rattus*	7.2
Black rat (female) *Rattus rattus*	17.9

Table 5. Acute toxicity of aflatoxin B1 in relation to selected animals (according to Sechczuk, 2002)

[1] LD_{50} median lethal dose – statistically calculated dose that causes death in 50% of the tested animals.

Ochratoxin A is a typical kind of a nephrotoxin that appears in improperly stored cereal grains, beans, soybeans, dried fruits, wine, coffee and animal source foods. Ochratoxin is mainly produced by species of the *Aspergillus* and *Penicillium* genera. This toxin is present in all climates and is the most common mycotoxin in Poland. It has been shown that 12% of cereals and 2% of feed is contaminated with ochratoxin. Ochratoxins cause irreversible changes in nephrons, as well as neurotoxic, carcinogenic and immunosuppressive effects (Wróbel, 2014).

Fumonisins are mainly found in maize and products made from it. Fumonisin B1, which is produced by *Fusarium proliferatum* and *F. verticillioides*, is especially important in toxicology. These toxins have carcinogenic effects in animals, and possibly also in humans.

Patulin is mainly produced by *Penicillium expansum* and many species of the *Aspergillus* genus. It is usually found in apples and their preserves, but can also be present in other fruits (grapes, peaches, bananas). It is teratogenic, carcinogenic and genotoxic. (Sparrow, 2014).

4. Summary

Mould has the ability to colonize a variety of ecological niches. As saprobionts that decompose organic matter of different origins, they occupy an important place in the global circulation of elements in the environment. Their commonness means that we are constantly exposed to each other. The answer to the question addressed in the tittle of this paper, is neither easy nor clear. Although mould are used extensively in biotechnology, medicine and the food industry, in many cases they have a negative impact on human health, causing serious respiratory and skin diseases. Likewise, toxins synthesized by moulds cause food contamination and consumer poisoning. Important factors that increase the negative exposure to mould in humans and animals are: humidity, lack of adequate ventilation in residential spaces and improper storage and holding of raw materials for food production. In order to limit the negative effects of the presence of mould in the air we breathe, we should prevent mould spores from penetrating into the rooms in which we live and work, maintain adequate humidity and ensure proper ventilation. Reducing the risk of mycotoxins contamination of food and feed can be achieved by controlling the storage conditions of products as well as controlling the quality of the raw material prior to its use in production. Such assessments should in particular refer to the degree of cereal dampness and the presence of mould in the raw fruit used in food industry. Moulds can be our friends or enemies depending on the place and the conditions of their occurrence. By limiting the exposure to the adverse effects of mould, we can use their natural metabolic properties to meet our needs and improve our comfort of life.

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Dung beetles and their role in the nature

Adam Byk, Jacek Piętka

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Summary:

Scarabaeoid beetles (*Scarabaeoidea*) inhabit all zoogeographical regions of the world. However, coprophagy as the type of nutritional specialization dominates among the scarabaeoid beetles. The number of dung beetles (coprophagous *Scarabaeoidea*) is estimated at about 7,000 species. There are about 460 of dung beetles species in Europe, and about 90 of dung beetles species in Poland. Dung beetles can be endocoprids (dwellers), paracoprids (tunnelers) or telecoprids (rollers). Endocopric species lay eggs directly into the dung, paracropic species dig earth tunnels of various lengths ending with brooding chambers beneath the dung, and telecopric species separate a portion of dung and roll it into round balls which are then transported, sometimes far from the original source of the dung, to a place where the beetles dig tunnels ending with brooding chambers. Such a variety of methods of using faeces by dung beetles cause an accelerated circulation of nutrients, increased soil aeration, plant spreading, and a reduction in the number of parasites (flies and nematodes). Among dung beetles presently encountered in Poland there are endocopric and paracopric species.

Key words: *Scarabaeoidea*, *Scarabaeidae*, *Geotrupidae*, dung beetles, scarab dung beetles, earth-boring dung beetles, animal faeces

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Whatever it is that dung beetle buries and abandons the next day, is by no means lost. Nothing is lost in the balance of life, the whole of the inventory remains constant. A small pellet of manure buried by an insect will make the neighboring patch of grass turn delightfully green. The ram will come over and pluck the whole patch, and thus the better the roast a man expects of him will be. Thanks to the dung beetle industry, we get a perfect bite of meat.

Jean Henri Fabre

Introduction

Insects are the most numerous group of animal species on Earth with their quantity estimated at around 1.5 million species. The largest group of the insects (over 400,000 species) belong to the order of beetles (*Coleoptera*). *Scarabaeoidea* is one of the superfamilies of the beetles, which inhabit all zoogeographical parts of the world. Most of them inhabit the tropical zone, and their number tends to rapidly decrease northwards (Tesař, 1957).

The *Scarabaeoidea* superfamily is dominated by a group of species that feed on animal dung (coprophages). The recently found dung fossils indicate the existence of dung beetles (coprophagous *Scarabaeoidea*) in the age of the dinosaurs, even before the evolution of mammals (Chin and Gill, 1996). Currently, the number of dung beetles is estimated at 7,000 species (Hanski and Cambefort, 1991).

In Europe, the dung beetles include primarily the representatives of two families: earth-boring dung beetles – *Geotrupidae* (approximately 60 coprophagous species) and scarab dung beetles – *Scarabaeidae* (approximately 400 coprophagous species).

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In Poland, the dung beetles fauna – formerly referred to by Hildt (1896) as "*Domestic dung beetles*" – represents approximately 90 species. However, the prevalence of several of these species is yet to be confirmed by new finds.

The systematic arrangement and nomenclature of the species have been adapted from the "*Catalogue of Palearctic Coleoptera*" (Löbl and Löbl, 2016).

Farther and deeper

The dung beetles (coprophagous *Scarabaeoidea*) are the Endocoprid (dwellers), Paracoprid (tunnelers) or Telecoprid (rollers) insects (Bornemissza, 1976). The Endocoprid species lay their eggs directly in dung or in

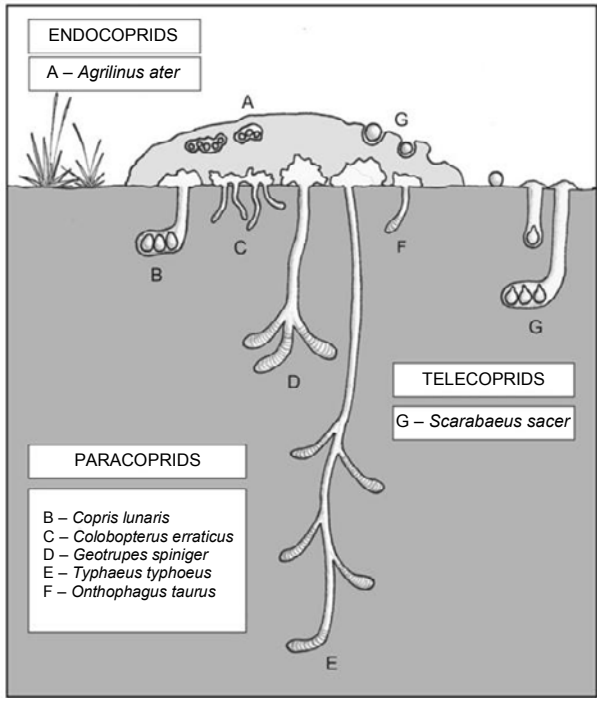

Fig. 1. Diagrams of dung beetles nests (drawn by J. Piętka).

the top layer of the soil, directly underneath the dung. The Paracoprids dig tunnels of various lengths in the ground, underneath the faeces. The tunnels are terminated with hatching chambers. As regards the Telecoprids, upon earlier separation and formation of a piece of dung, they roll it away and dig their tunnels, terminated with hatching chambers, at considerable distances from the dung. The chambers are used for storing the transported portions of the dung (Fig. 1).

The dung beetles commonly found in Poland include the Endocoprid and Paracoprid species (Byk, 2011; Byk, 2012; Kamiński, Byk and Tykarski, 2015).

The Endocoprid grouping is represented by aphodiine dung beetles (Fig. 2). They are the dominant coprophagous beetles in northern Europe and play a significant role in disposing of dung, and thus in circulating the natural organic substances and providing nutrients to the flora (Fry and Lonsdale, 1991).

Agrilinus ater (De Geer, 1774) (Fig. 2A) feed on fresh dung inside which females lay eggs. The eggs are laid as early as on the second day after the exposure of the dung, but most frequently within a period of 4 to 10 days after the exposure. The larvae prey in the vicinity of where the eggs are hatched (Hirschberger, 1998).

In the 19th and 20th centuries, a very beautifully colored dung beetle, *Acrossus bimaculatus*, (Laxmann, 1770) (Fig. 2B), was observed in the area of Warsaw. Here is what Hildt (1896) wrote about this particular species: "*One can tell that it is the prettiest specimen of the Aphodidae group. Glittering, as if it was covered in porcelain topping […]. An insect rarely seen in our region and nowhere to be found in some other years. […] I found one specimen in Saska Kępa in 1863. […] Another time, I found it in 1865 […] and on April 19, 1868, I found as many as forty of them in cow dung […]. The last one, I found in 1888 […] and haven't found a single one ever since*". In Poland, this particular species has not been

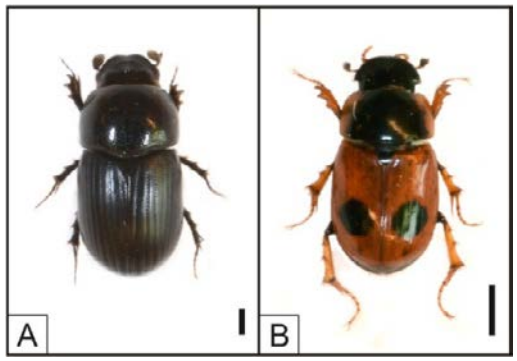

Fig. 2. Endocoprid aphodiine dung beetles: A – *Agrilinus ater*, B – *Acrossus bimaculatus* (photo by J. Piętka).

stumbled upon for nearly 100 years. In 1995, a site of the species was discovered near the village of Rudeńsk located close to Minsk in Belarus. Imagines and larvae were found directly in horse dung (Frolov and Akhmetova, 2006).

The aphodiine dung beetles grouping observable in Poland also includes species applying a slightly different method of using dung (Fig. 3).

Orodaliscus rotundangulus (Reitter, 1900) (Fig. 3A) lives in the burrows of speckled ground squirrel – *Spermophilus suslicus* (Güldenstaedt, 1770), bobak marmot – *Marmota bobak* (Müller, 1776) (Byk and Bidas, 2011), which is not present in our country, and little ground squirrel – *Spermatophilus pygmaeus* (Pallas, 1778) (Martynov, 2007). In Poland, this beetle is observed on extremely rare occasions, in the form of a single specimen, and is known to exist only on 5 sites located in the Lublin Upland. Strong populations of this species are found in the "Popówka" and "Suśle Wzgórza" reserves. The swarming of this species takes place during the last days of April or in the first half of May. The beetles leave the squirrels' burrows during the afternoon or evening hours. From a nest chamber located at a depth of 60-150 cm and a tunnel (latrine) extending from it, the beetles leave the site via a short and slanted corridor (elbow) and then, they climb up the side-walls of the vertical corridors (wells). It is both, males and females that leave the burrows, and after that, they bury themselves underneath a moist soil, at a close distance to the exit holes (Byk and Bidas, 2011). The presence of this beetle species in traps filled with cattle dung bait indicates their coprophagous genus (Piasecki, 2013).

Contrary to the Endocoprids, the *Colobopterus erraticus* (Linnaeus, 1758) (Fig. 3B), which is quite popular in our country, has a different way of behaving. A female of this species digs 4-10 curved tunnels in the soil, directly underneath the dung, at a depth of 3-5 cm (10-11 cm on rare occasions). She always lays eggs one-by-one in a small-size cavity in the soil, most frequently in the lower part of the tunnel. It takes the beetle a few hours to fill the tunnel (or rather its lower part referred to as larder) and to create a sausage-like breeding lump (brood mass). The mass weighs between 0.6 and 4 grams. It is about 7 mm in diameter and from 1.5 to 3.5 cm in length. It takes approximately 10 days for the female to build a nest with 8 tunnels filled with nourishment for the offspring. The larvae feed on the dung collected by the female and, should their supplies run out, they move close to the dung located right above them. The metamorphose takes place in the soil, at a depth of 12-13 centimeters (Rojewski, 1983).

The aforementioned is similar to how the largest and sporadically observed in our fauna *Coprimorphus scrutator* (Herbst, 1789) (Ryc. 3C) behaves. Over the recent years, this species has been observed in Skowronno near Pińczów (Bidas, 2004), Tylawa near Dukla, Huta Polańska near Krempna, Wojkowa near Krynica Zdrój (Bidas and Cieślak, 2006), Żubracze near Cisna, and in Przełęcz Wyżna near Wetlina (Zięba and Dworakowski, 2008). It inhabits cow dung on the mountain pastures.

These beetles copulate on dung and then each female digs directly underneath the dung 7-8 shallow and vertical tunnels. At the bottom of these tunnels, food is collected for the upcoming offspring and this is also where eggs are laid – always in the lower part of the breeding lump and in compliance with the "one tunnel-one egg" principle. At the initial stage, the larvae feed on food collected in the tunnels and switch to using the dung located above them at a later stage. Prior to the metamorphose stage, the larvae penetrate into the soil and build pupation chamber (Barbero and Palestrini, 1995). The last two dung beetles belong to the Paracoprid group of the species.

Typical Paracoprids (Fig. 4) are domestic species of the following genus: *Anoplotrupes* Jekel, *Geotrupes* Latreille and *Trypocopris* Motschulsky.

Dor beetle – *Anoplotrupes stercorosus* (Scriba, 1791) (Fig, 4A), is the most common and widespread member of the earth-boring dung beetles (*Geotrupidae*) that inhabits the forests of Poland. It digs 15-35 cm thick tunnels in the soil which are terminated with breeding lumps. Borowski (1960) made a comprehensive investigation into the nourishment spectrum of the dor beetle and presented it to the public. His analysis of the breeding lumps showed that they consist of fragments of leaves, including needles, pieces of bark, and rotting moss. They include no fragments of mushroom fruitbodies or rotten wood. The total amount of the mold buried by beetles of this species is about 1,400 kg per hectare. The most attractive food for the imago dor beetle is dung of large animals as well as decomposed mushroom fruitbodies. Plewińska (2007) points out to the high level of attractiveness of rodent dung for the dor beetle, which is even higher than that of cow and horse dung. She also draws attention to a significant contribution of this dung to the beetle's diet. Therefore, one may come to a conclusion that the dor beetle fancies

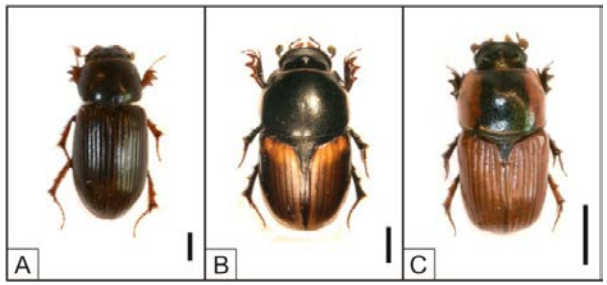

Fig. 3. Aphodiine dung beetles: A – *Orodaliscus rotundangulus* (photo by J. Piętka), B – *Colobopterus erraticus* (photo by T. Gazurek), C – *Coprimorphus scrutator* (photo by J. Piętka).

forests rich in rotten plants, animal faeces, and fungi. According to Teichert (1959), 7 pairs of the *Geotrupes spiniger* species (Marsham, 1802) (Fig. 4B) can bury over 12.6 kg of fresh manure during nesting. The mass of the dung buried by a single specimen exceeds by 560 times the mass of the beetle itself (Rojewski, 1980).

Another representative of the minotaur beetle – *Typhaeus typhoeus* (Linnaeus, 1758) (Fig. 4C) digs in the ground tunnels that are up to 100-150 cm deep (Brussaard, 1983). The nest of this species was once described by Fabre (1948), "*This time, it is no longer the chamber of the scarab, homed dung beetle, or other, which is easy to dug out with the help of a pocket hoe, but a shaft the bottom of which can only be reached by digging for a few hours with a solid shovel. For this work, with the sun still beating down, the hands and legs become numb. Oh, my poor, old bones! Sensing such an interesting riddle under the ground and yet not being able to dig!*" The minotaur beetle inhabits moorlands and pine forests on sandy soils where they feed on the excrements of rabbits, deer, roe, and sheep, more seldom of cows and horses (Burakowski, Mroczkowski and Stefańska, 1983). The beetles of this species are sometimes found under the carrion of large mammals (Byk, 2011). Nests are usually built directly under the dung or in their direct vicinity. Males and females work together while digging nests and transporting faeces. The females dig a tunnel and the males remove the excavated load of earth. The males put the faeces into the burrows where they initially grind it. In a sausage-like shaped hatching chamber, the females transform the faeces into a breeding lump about the size of a finger. An egg is laid in the soil under the breeding lump (Fabre, 1948). In laboratory conditions, the males first picked up the faeces located within a radius of 45 cm of the burrow entrance and then the faeces located at a greater distance. In the latter case, however, they often decided to dig a new entrance to the nest, and when the distance exceeded one meter, they usually left the nest and built new ones located closer to the faeces (Brussaard, 1983; Brussard and Visser, 1987).

Copris lunaris (Linnaeus, 1758) (Fig. 4D), which belongs to the scarab dung beetles, is a widespread species in our country. It likes to inhabit cattle and horse dung on sunlit pastures, sandy and loamy soils (Stebnicka, 1976a). The females dig in the ground, directly under the dung, a few centimeter-long tunnels that end with hatching chambers, where – together with the males – they store food for their offspring (Myrcha, 1973). According to Rommel (1967), the males of this species transport the dung to the entrance of the tunnel, and the females take it into the hatching chamber. At the next stage, the females use the dung (previously collected in the chamber) to sculpt it into 4-8 pear-shaped breeding lumps and lay single eggs in their upper section. The females, and sometimes also the males, remain in the hatching chambers to take care of their offspring. They protect the breeding lumps filled with larvae and pupae and leave the nests with adult offspring (Myrcha, 1973; Mašán and Halliday, 2009).

In Poland, a large group of the Paracoprid species is represented by *Onthophagus* genus. Quite a number of

these species are known for their sexual dimorphism. Males tend to have horn-like projections or even antlers. According to Fabre (1948), "*No bull specimen typical for Swiss pastures has horns so exquisite and so beautifully curved*" as the bull-headed dung beetle – *Onthophagus taurus* (Schreber, 1759) (Fig, 4A). It inhabits open sandy and limestone lands of xerothermic nature and the sunlit edges of forests (Burakowski, Mroczkowski and Stefańska, 1983). In our country, it is widespread in the pastures of the Bug River area. This beetle usually digs in the ground vertical sidewalks at the bottom of which a hatching chamber is built. Then, the side walls of the tunnel and the chamber are reinforced with the dung brought in from the outside. The egg is laid on one of the hatching chamber side walls, and then the chamber is filled with dung (Fabre, 1948; Halffter and Edmonds, 1982).

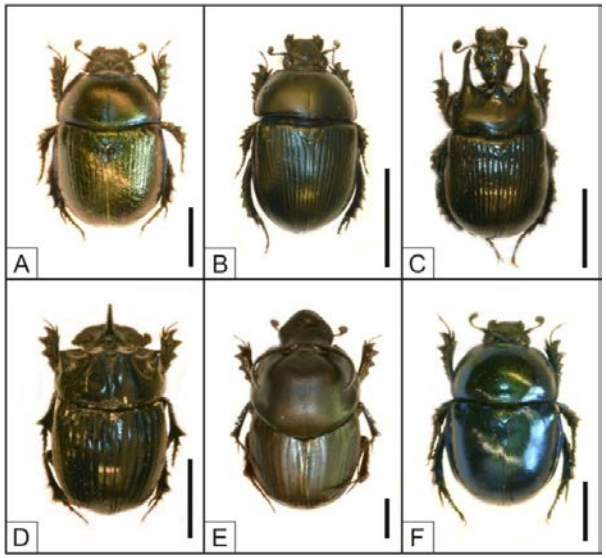

Fig. 4. Paracoprid dung beetles: A – *Anoplotrupes stercorosus* (dor beetle), B – *Geotrupes spiniger*, C – *Typhaeus typhoeus* (minotaur beetle), D – *Copris lunaris*, E – *Onthophagus taurus* (bull-headed dung beetle), F – *Trypocopris vernalis* (spring dor beetle) (photo by J. Piętka)

Sometimes, the minotaur beetle (*Typhaeus typhoeus*), and sporadically the spring dor beetle – *Trypocopris vernalis* (Linnaeus, 1758) (Fig. 4F), are able to roll the dung at short distances. However, the Telecoprids group (Fig. 5) has no representatives in our domestic fauna.

A typical telecoprid species, *Gymnopleurus geoffroyi* (Fuessly, 1775) (Fig. 5A), was first observed more than a century ago in the vicinity of Ustroń in the Cieszyn Silesia (Stebnicka, 1976a). According to Hildt (1896) this particular species, "*[...] inhabits every type of dung. They form balls about the size of a bean and then lay eggs in them. If they find the ground unsuitable, they roll the ball to a more appropriate location, where they bury it and themselves deep in the ground. Although, these beetles live in groups, each pair manufactures its own ball. […] They are totally absent in the Warsaw area. They appear only in the Radom Governorate and, more often, in the Hrubieszów district.*"

Sisyphus schaefferi (Linnaeus, 1758) (Fig. 5B), the second species of the Telecoprid group, was found over a century ago in Puławy and Janowiec of the Lublin Upland. It inhabits steppe areas, dry pastures, and mild sunlit slopes. Adults feed on cattle dung, particularly that of the sheep. The food is collected in the form of pear-shaped balls stored in underground chambers which is where these beetles lay their eggs. However, they fail to care for their offspring (Burakowski, Mroczkowski and Stefańska, 1983). According to Hildt (1896), *"It stays in fat manure and quite willingly in human excrements. It lives in pairs. Each pair forms little balls of the dung, buries them in the ground and lays eggs in them. They move in a clumsy, goat-like manner and with difficulty on even ground. […] In our country, they are observed mostly in the southern part of the Lublin Governorate; they are pretty popular in the Galicia. […] It is absent in the Warsaw area".*

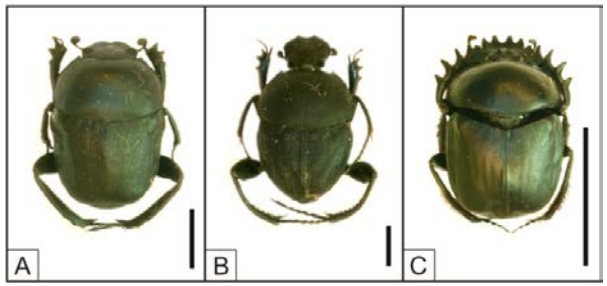

Fig. 5. Telecoprid true scarab dung beetles: A – *Gymnopleurus geoffroyi*, B – *Sisyphus schaefferi*, C – *Scarabaeus sacer* (sacred scarab beetle) (photo by J. Piętka)

Sacred scarab beetle – *Scarabaeus sacer* (Linnaeus, 1758) (Fig. 5C), is the third species of the Telecoprid group reported in our country several years ago. J. A. Wolf's collection included a scarab specimen from the Cracow area. We know this from Karol Herman de Perthées' notes archived in the Institute of Systematics and Evolution of Animals of the Polish Academy of Sciences (PAN). However, the specimen itself was destroyed during a fire at the University of Kiev (Śliwa, 2003). At present day, the closest sites of the scarabs are located in Hungary (*Scarabaeus typhon* (Fischer von Waldheim, 1823) and *S. pius* (Illiger, 1803) and Ukraine (*S. sacer* and *S. typhon*). In the 18th, 19th and early 20th centuries, the scarabs were also found within the areas of the present-day Austria, the Czech Republic, and Slovakia. In 1961, the *S. typhoon* scarab was found in Kováčov on the Danube in the southern part of Slovakia. According to Hildt (1896), *"Insects of this genus are not at all present in our region [...]. They are sometimes observed in the Podolia and Kherson Governorates [...] two specimens [...]. I found near the Rozdzielna railroad station"*. The city of Rozdzielna is currently located within the territory of Ukraine, approximately 60 km from

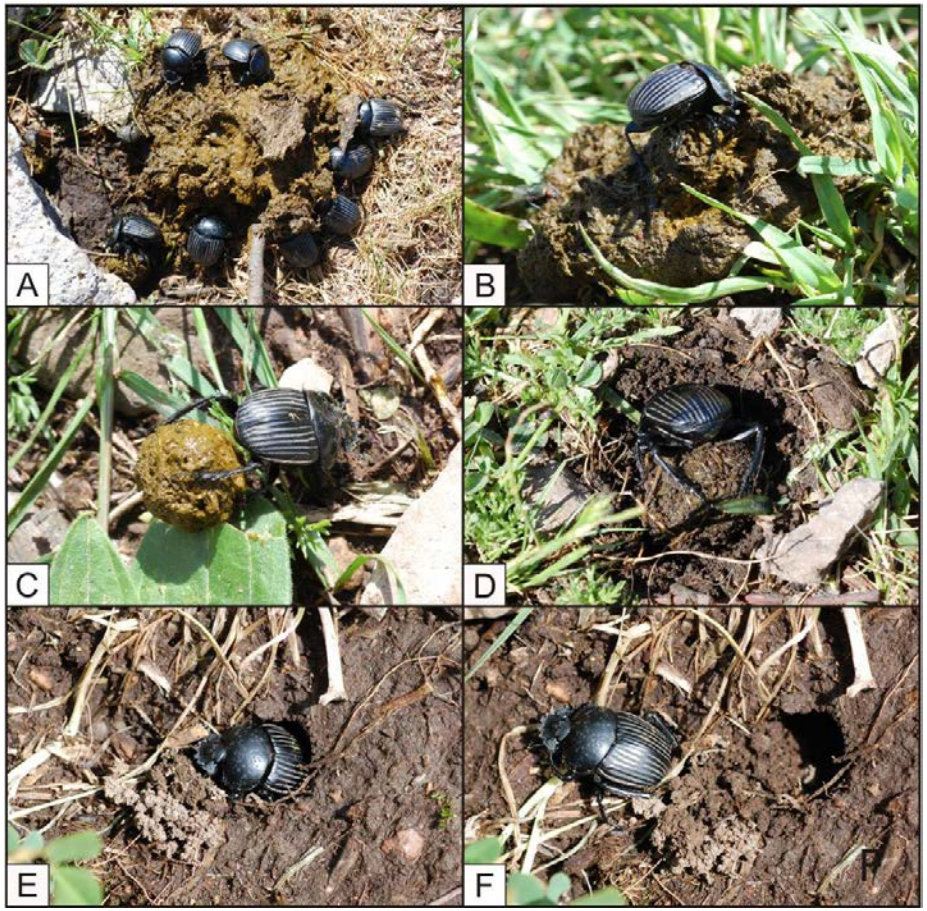

Fig. 6 A-F. *Ateuchetus laticollis'* dung handling method (photo by J. Piętka).

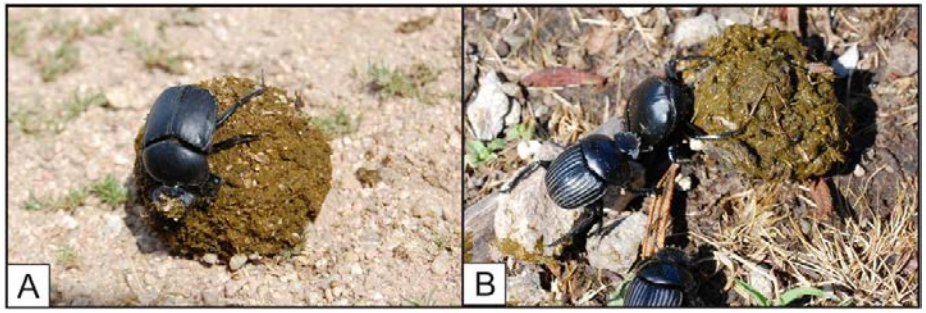

Fig. 7 A-B. An attempt to take over a *Scarabaeus typhon's* ball by 2 smaller scarabs (*Ateuchetus laticollis*) (photo by J. Piętka).

Odessa. The scarabs' natural habitat is fresh dung lying on the routes of the livestock (sheep, cows, and horses). The adult scarabs use their front section of the head and the legs (with distinctive tooth–like projections on the outer edges) to cut down portions of the dung.

On midsize pastures located near Cuglieri in Sardinia, the authors observed a swarm of *Ateuchetus laticollis* (Linnaeus, 1767) (Fig. 6) and the method the scarabs used to handle the dung. In the afternoon of a sunny May day, hundreds of specimens could be admired in the air and on the ground. One of the observed scarabs of this species cut the dung off and tentatively modeled a ball in 4 minutes. This beetle was vigorously moving his head and legs while turning around his own axis. After making suitably deep cuts, the pre-formed ball was separated from the rest of the dung under the weight of the beetle sitting on it. Next, the scarab embraced the ball with his hind legs and, standing still in vertical position with his head down, began to push his forelegs away from the ground, setting the ball in motion. Rolling a portion of fresh dung cut by the beetle caused its shape to become more spherical with its diameter reaching approximately 2 cm. Larger scarabs (3-5 cm in diameter) are able to roll balls much larger in size (3-5 cm) and the largest specimens are skilled enough to manufacture a ball as large as 6 cm. Quite frequently, the size of a ball exceeds that of the beetle itself (Byk and Piętka, 2011), and it is 10 to 20 times heavier (Doube and Dalton, 2003). The modeled ball of manure can be rolled by a scarab, or a pair of scarabs, even at a distance of several dozens of meters.

It is not uncommon that scarabs of the same species fight for the modeled ball. It happens that an individual who has put a lot of effort into modeling the ball is chased away by a stronger opponent. Sometimes, the specimens of two species, differing largely in size, compete for the ball. In Sardinia, the authors observed an

unsuccessful attempt to take over a ball of a giant *S. typhon* scarab by 2 individuals of the smaller *A. laticollis* (Byk and Piętka, 2011) species (Fig. 7).

Fabre (1948) described this behavior in the following way, *"I lack the more meaningful data to investigate the original causes of these dispossessions sanctified by tradition, of the abuse of power to gain a tiny bit of manure; I can only state that theft is a common practice amongst the scarabs. These dung-ball turners rob each other with unparalleled impudence."* The scarabs dig 10-30 cm deep tunnels in the ground. The tunnels are terminated with a large-size chamber where the scarab places the ball which he has rolled to the site. It is this chamber where copulation takes place. Afterwards, the male leaves the nest and the female stays inside to form 1-3 breeding lumps from the ball. She lays eggs in the narrower sections of it and then leaves and covers the burrow afterward. In her life cycle, a single female can make dozens of nests. The hatching period takes from 5 to 12 days, the larva period from 30 to 35 days, and the pupa period – approximately 14 days. After the transformation period, depending on atmospheric conditions, the young beetles remain in the breading lumps until late autumn or spring. Once the indoor growing period has come to an end, the majority of the manure, which has been digested by the beetles, is left in the nest and is used to enrich the soil with organic substances (Byk and Piętka, 2011).

The colder it gets, the lower the number of species

As we advance towards the south of Europe, the number of individuals of coprophagic species belonging to the *Scarabaeidae* family increases amongst the representatives of the *Scarabaeoidea* superfamily, both in open and forested areas. They are dominated by species of the following genus: *Onthophagus*, *Gymnopleurus*, *Sisyphus* and *Scarabaeus* (Balthasar, 1964). Concurrently, the number of individuals of the *Geotrupidae* species tends to be reduced (Byk, 2012). According to Hortal et al. (2011), no low-temperature adaptation mechanisms were developed amongst the representatives of the *Onitini* and *Scarabaeini* tribes that would allow new areas to colonized or the species to survive in northern Europe. Located in northeastern Italy, the La Mandria Park – a patchwork of the open and forested areas – as much as 94% of the coprophagous *Scarabaeoidea* were the *Scarabaeidae* (including 32.5% of the *Aphodiinae* specimens) and the *Geotrupidae* specimens constituted as little as 6% of the group (Barbero et al., 1999).

Across the pastures of Poland, the core of the coprophagous *Scarabaeoidea* groupings consist of the *Scarabaeidae*, but the *Aphodiinae* subfamily, i.e. the *Acrossus rufipes* (Linnaeus, 1758), *Agrilinus ater*, *Aphodius pedellus* (De Geer, 1774), *Bodilopsis rufa* (Moll, 1782), *Chilothorax distinctus* (Müller, 1776), *Colobopterus erraticus*, *Esymus pusillus* (Herbst, 1789), *Eupleurus subterraneus* (Linnaeus, 1758), *Melinopterus prodromus* (Brahm, 1790), *M. sphacelatus* (Panzer, 1798), and *Othophorus haemorrhoidalis* (Linnaeus, 1758) (Breymeyer, 1974; Stebnicka, 1976b; Bunalski, 1996a, b; Żuk, 2005; Górz, 2007). The core of the coprophagous *Scarabaeoidea* groupings in the forests of Poland are made by two species of the *Geotrupidae* – the dor beetle (*Anoplotrupes stercorosus*) and the spring dor beetle (*Trypocopris vernalis*). The core is sometimes supplemented by the *Acrossus depressus* (Kugelann, 1792), *A. rufipes*, *Aphodius pedellus*, *Chilothorax distinctus*, *Euorodalus coenosus* (Panzer, 1798), and *Planolinus fasciatus* (Olivier, 1789) (Szyszko, 1983; Szwałko, 1995; Byk, 2011, 2012; Byk and Węgrzynowicz, 2015; Kamiński, Byk and Tykarski, 2015). The dor beetle plays a particularly important role in our domestic forests. It is a frequent inhabitant of the pine forests growing on the wooded areas and is observed in much larger numbers in the forests growing on the former farmlands. By inhabiting the forest stands growing on the former farmlands, by digging tunnels and burying wild animal dung and rotten leaves, it changes the properties of the post-agricultural soil hollowing and speeds up the forest-type land forming process (Byk, 2004; Byk and Semkiw, 2010). The above considerations show that open areas (meadows, pastures, fallows) as well as wooded areas are inhabited by groups of dung beetles of different structure (composition and quantity of the species).

First come, first served

A large quantity of dung beetles forces individual species to compete for food of an ephemeral nature. It appears suddenly and disappears within a short time or is unsuitable to inhabit. The result of this competition includes, without limitation, the previously presented different strategies the Endocoprids, Paracoprids, and Telecoprids apply to deal with dung. It is also extremely important to have the time necessary to reach the dung. The "first come, first served" strategy has been adopted by a large group of Telecoprids. Quite often, the Telecoprids find dung within a few minutes after its appearance as only the fresh dung is suitable for modeling a ball. To do this, the scarabs sometimes follow directly a herd of sheep. Their rush was described by Fabre (1948), *"Who is that stepping so hastily, as if afraid of being late? Long legs are moving quickly and awkwardly as if set in motion by an invisible mechanism hidden in the insect's stomach; little red horns distributed in a fan-like manner – a sign of restless lust. Here it comes – it's already arrived running over a few fellow revelers. It is Scarabaeus sacer, the sacred scarab beetle"*. The Paracoprids and Endocoprids usually come to

dung within the first several days following the dung's appearance. The *Melinopterus* Mulsant or *Chilothorax* Motschulsky beetles of the *Aphodiinae* subfamily are usually there within the first few hours and the *Aphodius* Illiger and *Teuchestes* Mulsant – within the first few days. A similar way of conduct is attributable to the beetles of the *Geotrupes* and *Onthophagus* genera and the *Ammooecius* Mulsant genus is keen on inhabiting old dung, e.g. the one that appears in the spring once the snow has thawed. An unusual "sit and wait" strategy has been adopted by some of the tropical species of the *Canthon* Hoffmannsegg genus. The amount of dung in neotropical forests is limited due to small quantities of large vertebrates, and for this reason finding the location of dung is an important element of the survival strategy. Beetles which first come to dung have an advantage over those arriving at a later time. The coprophagous tumblebugs (*Canthon sp.*) dwells in areas located close to the anus of arboreal monkeys – the brown-haired *Callicebus brunneus* (Wagner, 1842) titi and *Pithecia irrorata* (Gray, 1842) saki monkeys. The imagines of this beetle inhabit ape dung already during defecation and fall from the trees down on the ground together with the dung (Jacobs et al., 2008). A similar way of conduct is attributable to species of the *Uroxys* Westwood and *Pedaridium* Harold genera. They inhabit the sloth's fur and leave it with their hosts' dung in which they continue to feed and lay their eggs (Halffter and Mathews, 1966; Ratcliffe, 1980; Howden and Young, 1981; Waage and Best, 1985). In Australia, 6 species of the *Onthophagus* genus dwell on marsupials. They cling on the marsupial's fur thanks to a specific structure of their claws (Matthews, 1972b). They also fall to the ground together with the marsupials' dung where they continue to develop.

What's in it for us?

The dung beetles (coprophagous *Scarabaeoidea*) play an extremely significant role in natural ecosystems, especially in the circulation of elements and secondary dispersal of seeds (Nichols et al. 2008). According to Rojewski (1980), Bunalski (1995) and Górz (1999), the role of the coprophages in meadow ecosystems consists in:

- Preventing the occurrence of the "dung pollution" phenomenon by reducing the mass of animal dung;
- Stimulating the dung mineralization process by burying and grinding it;
- Aerating and improving the structure of the soil by digging tunnels at various depths;
- Improving the amount humus in the soil by burying the dung;
- Reducing the number of coprobiontic dipterans (including the bloodsucking species);
- Reducing the quantity of parasitic nematodes by crushing their eggs.

According to Rembiałkowska (1980), the role of the pasture and forest species of the dung beetles is similar and consists in grinding and mixing of the soil with faeces of different species of mammals. A slightly different role is played by the dor beetle, which enriches the deeper, mineral layers of the soil with organic matter by burying the forest litter in the form of breeding lumps. This is of special importance for meager forest habitats where saprophagous macrofauna, e.g. earthworms, is rarely observed. The commonness and the role of the dung beetles are best evidenced by numbers:

- 10 specimens of the minotaur beetle (*Typhaeus typhoeus*) species can bury around 400 balls of rabbit dung in 25 days (Spaney, 1910);
- On a pasture located near Berlin, there were 825 specimens of the aphodiine dung beetles, 38 specimens of the earth-boring dung beetles and 70 specimens of the *Onthophagus* genus dwelling in a portion of sheep dung, and 92 specimens of the *Geotrupes stercorarius* (Linnaeus, 1758) (Burmeister, 1936) species were found in a portion of horse dung;
- European species of the earth-boring dung beetles during the nest building period bury approximately from 0.2 to 0.7 kg of dung (Teichert, 1959);
- In Algeria, some 450 specimens of the *Gymnopleurus* genus and 190 other dung beetles in a single, Ø35 cm portion of cow dung, and 31 scarabs in another portion of dung (Balthasar, 1963) were observed;
- In Algeria, 80 beetles of the *Thorectes* Mulsant genus and *Stereopyge* A. Costa subgenus were observed on each square meter of a cornfield with freshly dispersed manure; each of these beetles buried 20 grams of dung; therefore, 800,000 specimens buried almost 16 tons of dung per hectare (Balthasar, 1963);
- In the Johannesburg area, there were usually 400 specimens of the *Aphodiinae* subfamily, 50 specimens of the *Onthophagus* genus, 50 specimens of the *Oniticellus* genus, 40 specimens of the *Onitis* genus, 2 specimens of the *Copris* genus, and 5 specimens of the *Sisyphus* genus (Gillard, 1967);
- Parasitic flies of the *Haematobia irritans* (Linnaeus, 1758) species cause approximately $730 million in losses to cattle farming (Drummond et al., 1981), while the dung beetles can reduce the number of these flies by as much as 95% (Bornemissza, 1970, 1976);
- Under laboratory conditions, a pair of specimens of the *Onitis* genus can bury 0.7 kg of dung within 10 days' time (Doube and Dalton, 2003);

- It is estimated that the dung beetles allow the US farmers to save $380 million a year (Losey and Vaughan, 2006).

The key evidence of the tremendous importance of the dung beetles for nature is the role they played in Australia. In 1778, the Europeans settled in Australia and brought with them many species of crops and livestock. As cattle farming developed across the entire country, along came unprecedented pollution of pastures with dung (the so-called dung pollution) as well as the mass emergence of flies developing in the dung. Unfortunately, it also included the parasitic and bloodsucking species. Due to dung pollution, the area of pastures available to animals was rapidly decreasing. Under the country's climatic conditions, the dung quickly dried up and turned into "crust" that remained in place for several years. For this reason, the further development of sheep, cows, and horses has been questioned. The main reason for this was the lack of native coprophages that could grow in the cattle dung. Therefore, further development of sheep, cow and horse farming became pretty questionable. The main reason of this situation was the lack of domestic coprophages that could develop in animal dung. Domestic dung beetles have evolved together with the marsupials and failed to adopt the process of inhabiting cattle dung (Tyndale-Biscoe, 1971; Mathews, 1972b). Dung beetles in Africa, Asia, and Europe have evolved together with large ruminants and learned to use their faeces (Waterhouse, 1974; Bornemissza, 1976). It was, therefore, accepted that they could accelerate the dung decaying process on Australian pastures, so they were put to work. Between the years of 1970 and 1980, over 50 species of African and European dung beetles were sent from South Africa to Australia as part of the "Dung Beetle Project". 43 species of the dung beetles successfully passed the incubation and quarantine process and were then released to the pastures. As a result, a number of pastures polluted with dung drastically decreased. The key "heroes" included: gazella scarab – *Onthophagus gazella* (Fabricius, 1787), northern sandy dung beetle – *Euoniticellus intermedius* (Reiche, 1850), alexis dung beetle – *Onitis alexis* (Klug, 1835), humpbacked dung beetle – *Onthophagus binodis* (Thunberg, 1818), and bull-headed dung beetle (*Onthophagus taurus*) (Edwards, 2007).

> *From among the insects that defend us against dangerous waste, shamelessly decaying in the rays of sunshine, dung beetles deserve most of the attention* (Fabre, 1948).

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Red fox (*Vulpes vulpes*) as a synurbic species and its role in the spread of the Echinococcus multilocularis tapeworm

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Summary:

Urbanization of the environment contributes to the degradation of many natural habitats of many plants and animals, which causes reduction of biodiversity. There are however certain species, adapting easily to both suburban and urban conditions. Red fox (*Vulpes vulpes*) is a good example, since it is increasingly noted not only in the natural habitats, such as fields or forests, but also in the direct vicinity of human residencies like farms, suburban areas or even large agglomerations. Fox is becoming a permanent feature of urban fauna, enriching the biodiversity. It is also a relevant epidemiological threat, constituting a zoonotic reservoir for many parasites which are important from veterinary, as well as from medical point of view, including tapeworm *Echinococcus multilocularis* which causes alveolar echinococcosis.

Key words: red fox, rabies, scabies, alveolar echinococcosis, hunting, parasites, *Echinococcus multilocularis*

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Introduction

The progressing urbanization process causes the displacement of numerous plant and animal species from their current habitats, thus contributing to the reduction of biodiversity (Vitousek et al., 1997; Hunter, 2007). However, some animals are capable of overcoming the fear of humans and learn how to use new ecological niches resulting from human activity. The process of species emerging in urban areas is referred to as synurbization (Andrzejewski et al., 1978). Due to the synurbization, animals acquire new skills to live and utilize new sources of food and to reproduce in the vicinity of humans (Champan & Jones, 2012; Luniak 2008). The species observable in cities include, inter alia, rodents: the striped field mouse *Apodemus agrarius* (Babińska-Werka et al., 1979), the red squirrel (*Sciurus vulgaris*), (Verbelyen et al., 2003); birds, including the peregrine falcon (*Falco peregrinus*; Rejt, 2001), and larger mammals, e.g. the badger (*Meles meles*), (Harris, 1984). The red fox (*Vulpes vulpes*) is also coping well in urban areas, thus enriching the urban fauna. However, the red fox is a zoonotic reservoir of parasites which can pose danger to human and animal health.

Biology and prevalence

The red fox is a predator belonging to the canids family. Mature specimens reach an approximate weight of 5–6 kg (Fig. 1). Females are smaller than males. The red fox breeds once a year, during winter months. On

Fig. 1. Adult foxes

Source: http://dinoanimals.pl/zwierzeta/lis-vulpes-vulpes-rudy-spryciarz/attachment/lis-dinoanimals-pl-5/

average, 3–5 pups are born which become self-sufficient after 3 months. The female cares for the young and the male helps feed the offspring by bringing the food near the burrow (http://animaldiversity.org/accounts/Vulpes_vulpes/#reproduction). It is the most common practice for foxes to dig burrows in a sandy ground (Scheldon, 1950) or to inhabit or even share the burrows dug by other animals, mainly the badger.

The fox is the world's most widespread predator (www.iucnredlist.org). It is present in Europe, North America, Asia, and it was also brought to Australia. It prefers field and forest habitats, mid-forest woodlots, and forest edges. The red fox is an omnivorous animal that mainly hunts for small-size rodents (Jędrzejewski & Jędrzejewska, 1992; Dell'Arte et al., 2007). The research on fox's food base conducted in north-eastern Poland shows that voles are the main source of food for these predators. In addition, it has been stated that male and young foxes have a wider food base than females. The percentage of rodents in the diet increases in autumn and winter seasons (Kidawa & Kowalczyk, 2011). The fox is an undesirable neighbor of poultry breeders. It can penetrate into farmlands, farms, and chicken coops where it has access to easy prey, ultimately leading to economic losses (Panek & Breziński, 2002; Jankowiak et al., 2008; Baker et al., IFAW.org.).

Fox population limiting factors

The main factor that limits the fox population is rabies; however, the associated threat was effectively eliminated through vaccines spread on a massive scale across the forest areas. Since 1978, as many as 24 European countries have been included in the program aimed to eradicate rabies. In 2007, the territory where fox vaccination campaigns were carried out, amounted to 21,077,370 km^2 (Freuling et al., 2013). According to the World Organization for Animal Health (OIE), countries where no single case of rabies have been detected, are considered virus–free. In Europe, such countries include, inter alia, the Netherlands (Clinguet et al., 2004), Austria (Muller et al., 2012), and Switzerland (Zannoni et al., 2000). In Poland, several dozen cases of rabies are reported on an annual basis (97 in 2015 with 70.1% relating to the red fox). Each case of rabies originated from the following 5 voivodships: Warmińsko-Mazurskie, Zachodnioporskie, Lubelskie, Małopolskie, and Podkarpackie (Flis, 2017). The specimen fallen due to rabies are found in the vicinity of human habitats (http://www.nowiny24.pl/wiadomosci/krosno/art/6137625,uwaga-wscieklizna-w-krosnie,id,t.html).

Fig. 2. Fox infected with scabies.

Source: http://www.nfws.org.uk/mange/mange_gallery.html

Another factor that impacts the size of fox population is scabies. Scabies is classified in the group of infectious diseases caused by small-size mites (*Sarcoptes scabiei*). It is a widespread parasite that attacks 104 species of domestic and wild animals across Europe, North and South Americas, Australia, Asia, and Africa (Bornestein et al., 2001). It may be the cause lying behind human scabies (Madhusudhan Bandi & Saikumar, 2013; Currie et al., 2004; Walton et al., 1999).

These small parasites are present in the host's skin tissue into which they burrow while feeding on the living tissue, tissue fluids, and epidermis (Arlian & Vyszenski-Moher, 1988, https://www.cdc.gov/dpdx/scabies/index.html).

The course of this disease depends on the condition and immune system of the animal. The most commonly observed symptoms include extensive allergic reactions, shedding, weight loss, and apathy (Little et al., 1995), (Fig. 2.). An extensive infection may lead to the death of the animal (Newman et al., 2002).

Scabies was the main cause of death in the population of foxes (particularly amongst the young specimens) monitored within the Bristol area between 1996–2007. In addition, it was demonstrated that females infected with this particular parasite had smaller litters and the puppies were in a much worse condition as compared to non-infected specimens (Sousbury et al., 2007). Death rate amongst the fox population prior to the emergence of scabies was approx. 10% per annum. After reporting the first infected fox in autumn of 1994, the death rate increased to 55% in the autumn season. Among the reported causes, scabies was the cause of 91% of fox deaths between the period of autumn 1994 and winter 1995. In addition, it was observed that the Bristol areas inhabited by fox family groupings had increased from 29.5±12.1 ha in 1990 to 209.6±127.5 ha in the winter season of 1995 (Baker et al., 2004). It was proved that, in the winter, foxes infected with scabies are less scared of people and are more frequently keen on selecting easily accessible sources of food (such as garbage) as compared to healthy specimens. The process of approaching human habitats and feeding the infected specimens may result in spreading scabies amongst humans and domestic animals (Cricondo-Sanchez, 2017).

In addition, the size of the fox population is also significantly impacted by hunters' activities. The red fox is a game animal and the hunting season in Poland lasts from June 1 to March 31. In areas where the pheasant, capercaillie or hare are reintroduced, the fox hunting season can last all year. Nevertheless, the Polish population of foxes remains high. Between 1980 and 2006, there was a continuous increase in the number of foxes in central Poland (Goszczyński et al., 2008). Despite the hunting activities, high concentrations of the species were observed in surveys conducted between 1998/1999 and 2006/2007 in the eastern and central regions of the country. Interestingly, the largest number of foxes in the smallest survey area were recorded in the Bialskie district, while the smallest number in the largest survey area was reported in the Siedlce district (Bombik et al., 2014). In western Poland, over the 5-fold higher density of this predator was recorded between 1997 and 2000 as compared to 1970 (Panek & Breziński, 2002). According to the Polish Hunting Association, the fox population in Poland was estimated at 200,000 in the 2011/2012 hunting season (www.pzlow.pl, Fig. 3). In 2013, the population was estimated at 208,200. By the spring of 2015, it had slightly decreased and was estimated at 191,000 specimens. To summarize, over a 4-fold increase in the population of this predator has been observed as compared to the years preceding the application of the rabies vaccines (Panek & Budny, 2015).

The red fox in urban areas

This particular predator accustoms itself perfectly to urban areas (Soulsbury et al., 2010; Lombardi et al., 2017) (Fig. 4). Fox concentrations in urban areas may reach quite high values (Harris & Baker, 2001; Gosselink et al., 2003). In Estonia, the presence of foxes was reported in 33 of 47 large cities. The existence of fox burrows was reported even in downtown areas. Foxes are capable of entering households, thus posing a direct threat to humans and domestic animals. Several cases of dogs and cats attacked by foxes have been reported (Plumer et al., 2014). In Switzerland, fox burrows with offspring were reported in 20 large cities (Gloor et al., 2001).

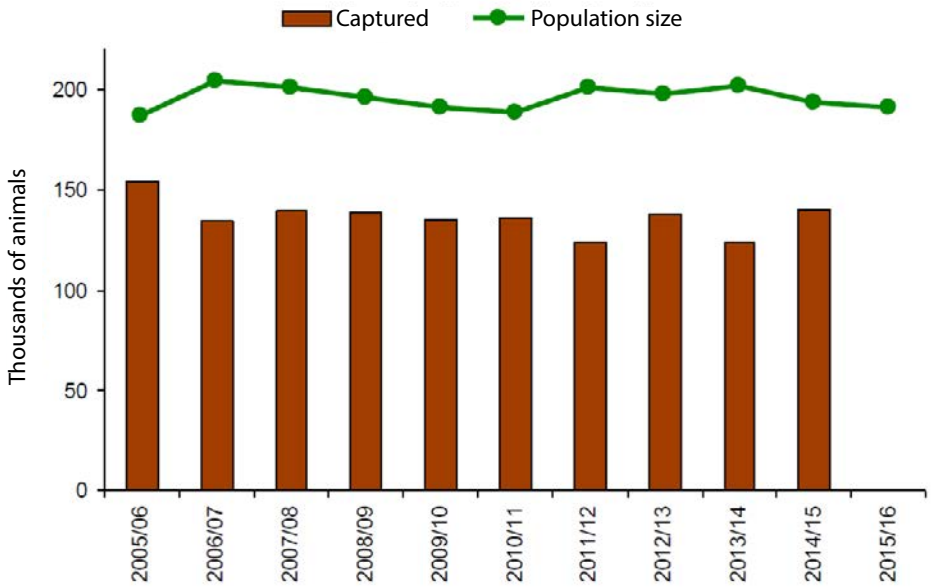

Fig. 3. Fox population in Poland

Source: www.pzlow.pl

Fig. 4. The red fox in city streets

Source: http://www.athensvoice.gr/kosmos/alepoy-neo-katoikidio-toy-londinoy

Specimens dwelling in urban areas are often spotted around dumpsters or in backyards (https://www.youtube.com/watch?v=IHeVJQPoy_w). As much as 80% of the content of the urban area fox digestive systems may comprise food of anthropological origin (Contesse et al., 2004). Animals inhabiting urban areas must cope with intensive road traffic which poses a direct life threat. Foxes can adapt their migrations to the type of crossed roads by selecting a small–traffic route and by crossing these routes at nighttime when traffic is at its lowest. Most frequently, the roads are crossed by males and the young while searching for a new territory (Baker et al., 2007). Adaptive skills, ability to use new sources of food and wide food base enable intensive expansion of the red fox to new areas, including downtowns (Bateman & Fleming, 2012).

Cyclophyllid tapeworm (*Echinococcus multilocularis*) and multilocular echinococcosis

The red fox is a host for a number of dangerous parasites. By accessing urban areas, it increases the risk of exposure to the worms that pose danger from the medical and veterinary perspective. The cyclophyllid tapeworm (*Echinoccocus multilocularis*) poses the highest risk for humans. A mature tapeworm, measuring approximately 2–5 mm in length (Fig. 5), dwells in the fox's and less frequently in the dog's and cat's intestines. The infection may be very intensive and may exceed as many as 10 000 tapeworms per specimen (Hoffer et al., 2000). Rodents are intermediate hosts of the tapeworm (https://www.cdc.gov/parasites/echinococcosis/biology.html). Currently, the *E. multilocularis* is assumed to be a global problem (Davidson et al., 2012). Tapeworms are common in numerous European countries, including Germany (Tackman et al., 1998), Slovakia (Dubinsky et al., 1999), Denmark (Saed at el., 2006), and Sweden (Osterman et al., 2011). It also extends to Asia (Giraduoux et al., 2013) and North America (Jenkins et al., 2012). It is widely spread amongst the foxes inhabiting the urban areas of Japan (Tsukada et al., 2000). In Poland, the cyclophyllid tapeworm has also been reported (Karamon et al., 2014) with the largest range of infections registered in the foxes caught mainly in the Warmińsko-Mazurskie, Podkarpackie, and Mazowieckie Voivodships (Karamon et al., 2015), (Fig. 6.). The factors providing the favorable conditions for the spread of the parasite include, first and foremost, the quantity and synanthropization of the fox (remaining in the immediate vicinity of humans). In environments contaminated with fox excrements and tapeworm eggs, infected rodents may emerge that will fall prey to domestic cats and dogs. Ultimately, these specimens will become the end hosts of the tapeworm and excrete eggs that are invasive to humans (Deplazes et al., 1999; Knapp et al., 2016). It has been proved that, in urban conditions, this parasite may close its life cycle on the basis of synanthropic species of rodents, i.e. the intermediate hosts. *E. multilocularis* cysts (larvae) have been reported in the European water vole (*Arvicola terrstis*) caught in Zurich (Hofer et al., 2000). Numerous studies confirming the presence of the *E. multilocularis* in foxes inhabiting the urban areas of many European countries, (Fisher et al., 2005; Robarded et al., 2008), show the widespread presence of this particular parasite posing potential risks for humans. Humans are threatened by contact with fox excrements and excrement–contaminated soil, e.g. in suburban gardens, parks, or forests.

The parasite causes an illness referred to as multilocular echinococcosis. The first case of the disease was described by Buhl in 1852 (Hosemann et al., 1928). Humans contract this disease by swallowing tapeworm eggs, thus becoming accidental hosts (Fig. 7). While in a human body, the larva hatches from the egg and, as it is not surrounded by any connective tissue, it quite easily spreads with blood and lymph to other organs (Czapliński & Kurnatowski, 1999). The studies conducted in Germany on a group of 120 patients with confirmed echinococcosis show that persons at risk of exposure to *E. multilocularis* include inhabitants of rural areas, dog and cat owners, persons who either consume

Fig. 5. *Echinococcus multilocularis* – adult form

Source: http://research.vet.upenn.edu/Default.aspx?TabId=7812

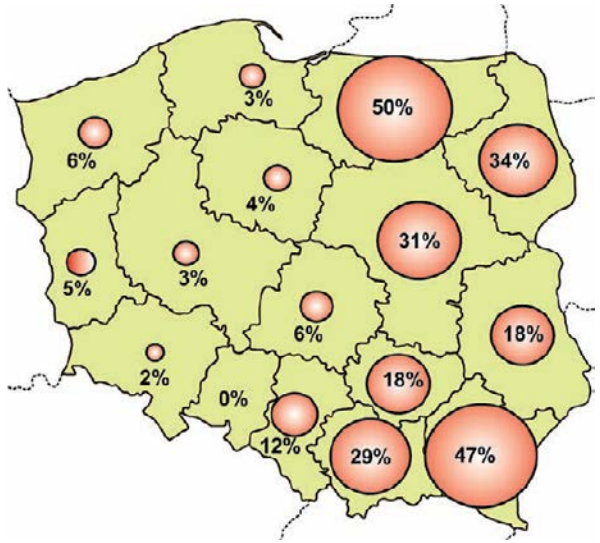

Fig. 6. Foxes infected with *E. multilocularis* between 2009–2013 in Poland

Source: Karamon J, Kochanowski M, Dąbrowska J, Różycki M, Bilska-Zając E, Sroka J, Cencek T (2015). *Echinococcus multilocularis* w Polsce – sytuacja epizootyczna u lisów wskaźnikiem ryzyka zarażenia ludzi. Życie Weterynaryjne 90(9)

unwashed fruits, vegetables, and grass or collect wood in forests, and persons with occupations related to forest areas (Kern et al., 2004). Traces of tapeworm DNA were discovered on fruits, vegetables and mushrooms originating from the Warmińsko-Mazurskie Voivodship, i.e. the area of Poland assumed to be endemic for the cyclophyllid tapeworm. The parasite's genetic material has been discovered with the use of molecular biology methods featuring sensitivity rates of above 100 eggs per tested sample. This proves the high significance of the food contaminated with eggs as a direct source of risk to humans. This is why it is important to educate communities living in areas endemic for *E. multilocularis* on means of prevention and threats resulting from failure to adhere to hygiene rules while preparing meals of fruits and vegetables that may contain tapeworm eggs (Lass et al., 2015). It is worth noting that the eggs of this particular tapeworm show extreme resistance to environmental factors. At 4 °C, they preserve the ability to remain immune to any type of intrusion for 478 days and for 240 days at -18 °C. It is not until the temperature reaches -83 °C / -196 °C that the eggs are killed within 48 / 20 hours respectively. The eggs are also immune to numerous chemical agents (Veit et al., 2009). The echinococcosis development process is similar to the development of cancer, with which the echinococcosis is often confused, and may last from 10 to 15 years. In case of non-treatment or improper treatment due to misdiagnosis, it may lead to death. Unfortunately, despite the quick diagnosis and properly selected therapy, the patient will ultimately lose his battle with the disease (Davis et al., 1986). It often happens that the symptoms are non-specific and depend on the location of the cyst in the body. Cysts are typically located in the liver, less commonly in the brain, heart or lungs. The non-specific symptoms include, inter alia, weight loss, upper and lower abdominal pain, hepatitis, apathy, ascites, swollen

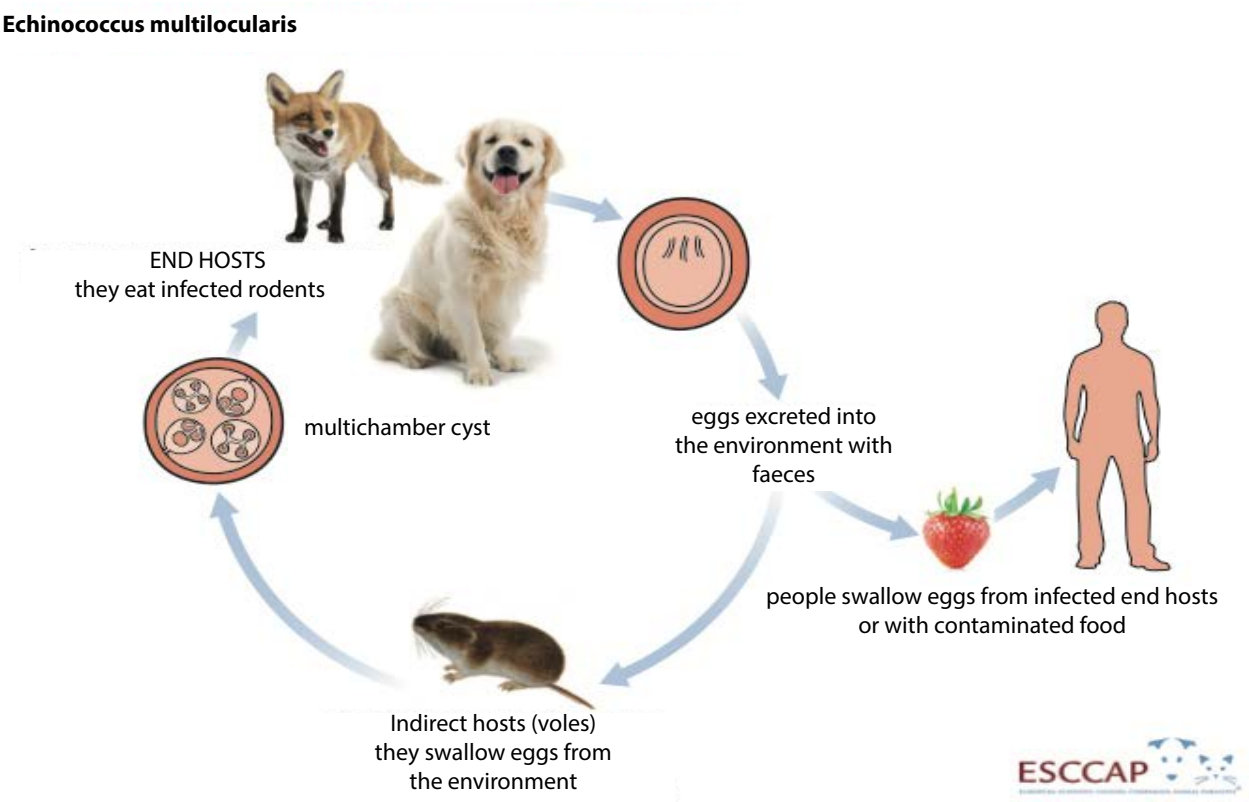

Fig. 7. The life cycle of *E. multilocularis*

Source: http://esccap.pl/wpcontent/uploads/2017/08/Cykl_rozwojowy_bablowiec_wielojamowy_Echinococcus_multilocularis.png

shanks, tachycardia (Pawłowski et al., 2001; Parfieniuk et al., 2009). The most effective method of removing the tapeworm is the surgical removal of cysts and long-term drug treatment based primarily on anti-parasitic medicine such as Albendazole and Mebendazole (Brunetti et al., 2010). The cases of multilocular echinococcosis are reported mainly in France (Pirraux et al., 2011), Germany (Romig et al., 1999), Lithuania (Sarkunas et al., 2010), and Switzerland (Schweiger et al., 2007). The first descriptions of multilocular echinococcosis patients in Poland come from 1951 and 1958 (Sowiakowski, 1955; Głuszcz & Kalczak, 1960). Between the years of 1990–2011, an increased number of multilocular echinococcosis cases was reported. The majority (57.3%) of the cases were reported in the Warmińsko-Mazurskie Voivodship believed to be an endemic region for *E. multilocularis*. Research conducted for over 20 years has included 121 cases of echinococcosis registered by the

Chief Sanitary Inspectorate. It included the ELISA and Western Blot tests that enabled the discovery of specific antibodies to the parasite in the patient's serum. In several cases, molecular biology methods (polymerase chain reaction; PCR) were also applied to discover the parasite's genetic material (Nahorski et al., 2013).

Summary

The red fox is a predator well–accustomed to dwell in all types of environments from forests to big city downtowns. Despite several significant factors that limit its quantities, an increase in this predator's population has been observed across a number of countries. This particular species enrich the urban fauna by becoming its permanent element. However, the presence of the fox in the vicinity of humans brings along a threat from the parasites for which the predator serves as the host. The most dangerous is the cyclophyllid tapeworm (*E. multilocularis*) causing multilocular echinococcosis – a deadly disease for humans. Monitoring the fox population and continuing the research on *E. multilocularis* may help take actions to prevent the infection process.

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Importance of digital spatial data in environmental education

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Summary:

The article describes the importance of spatial data resources and GIS tools in environmental education. Data resources available at European and national level and possibilities of their use in education have been presented. Assessment of usefulness of these resources for environmental education objectives was made. Examples of use of spatial data in environmental education are presented.

Key words: sustainable development, spatial data, GIS, environmental education

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Introduction

Spatial data[1] together with the tools for its visualization play a significant role in the environmental education. This issue is a point of interest to environmental stakeholders and GIS professionals. At the same time, however, it is also a point of interest to a number of social groups responsible for broadly sensed environmental education – both at the stage of school and academic education as well as the less formal education outside of school. The authors have adopted the following assumptions regarding the understanding of the term "environment" and its details, and consider the natural environment to be consisting of natural (both living and non-living) interrelated (systemically) and interacting components. Geographical environment is defined as a natural environment including some elements resulting from the human activity, i.e. anthropogenic elements (Jackowski, 2004).

The aim of this article is to identify and summarize public spatial data sources available at the European and national level and to discuss some opportunities for implementing them into the environmental education. Furthermore, answers were given to the following two questions: a) which public spatial data resources facilitate research and education projects related to ecology and sustainable development, and b) which geoportals should be used in environmental education and in implementing and presenting the ideas of sustainable development.

The importance of spatial data in environmental education

The great importance of spatial data in environmental education has been emphasized in reports, declarations and publications concerning such education for several decades. In the United States, the postulates to introduce GIS tools and methods to natural, geographic and ecological education were presented almost 25 years ago (Palladino, Goodchild, 1993) and again 10 years later (Kerski, 2003). A comprehensive program to introduce GIS technologies into secondary education was established there in 2007 (NRC 2006). This coincided with the emergence of interactive maps, first geoportals and free of charge publication of some spatial data on the Internet. Up until 10 years ago the difficulty of accessing appropriate software (GIS) – and above all accessing spatial data – was continually emphasized. The rapid development of GIS software has triggered the demand for both raw data (data that require processing with appropriate software) and interactive maps and geoportals[2]. Since 2007, a lot has changed in terms of the availability of information technology and GIS tools. Open source software has spread and expanded, and some GIS features have been transferred to web applications and made available online as webGIS applications. The greatest progress has been made, however, in the availability of spatial information including spatial data. They are of great importance in environmental research and education, including education for sustainable development. With the use of GIS tools and applications, they allow for a comprehensive analysis of the correlation between human activities and the state of the natural environment and the changes taking place in it.

Using interactive maps with database access (Milson, Kerski, Demrici, 2012, Kerski, 2012) allows teachers and academic and school students to answer the following questions: 1) why are the studied objects located in a given *place*? 2) why and how do *locations* differ from each other? 3) how varied and variable is the peo-

1 Spatial data – referring to a particular location in the geographical space

2 Geoportal – a portal for searching and accessing spatial information and its visualization via the internet

ple's interaction with the environment (*living places*) in the course of time and in the space? These aspects are closely linked to the need for providing education on sustainable development and to spatial data usage in doing so. The third one is, in fact, a question of the balance between economic, social, cultural and environmental concerns. Asking these questions and looking for answers is crucial to the education at the level of secondary, technical college and university education.

In the draft of a new geography curriculum for general secondary school and technical colleges, geographical information systems (GIS) were given a special role in learning about the world and detecting the complex problems of the geographic environment. The use of GIS in teaching geography has been included in the requirements, so after the implementation it will be biding to all geography teachers (Szkurłat et al., 2017).

The discussion on environmental education was initiated at the World Summit on Sustainable Development in Johannesburg in 2002, where the participants recommended adopting the Decade for Sustainable Development to be considered by the UN General Assembly. The implementation of the Summit in the area of geography was undertaken by the Commission on Geographical Education that operates within the framework of the International Geographical Union. The Lucerne Declaration on Geographical Education for Sustainable Development (2007) was adopted at the International Geographic Union Conference in Lucerne in 2007. It demanded to raise the importance of information and communication technologies (ICTs) including *Geographic Information Systems* (GIS) tools in environmental education[3]. At the same time, it brought attention to difficulties in accessing relevant data in this field, as well as issues related to the availability of hardware and software.

Overview of public spatial data resources and their relevance in environmental education

In the early years of GIS development, software distribution companies provided paying users with spatial data (usually it was data on administrative borders). The actions taken in 1990s by an American agency – *The National Spatial Data Infrastructure* (NSDI) – to "liberate spatial data" represented an important step in facilitating users' access to spatial data. As a result of these actions, the data that was mainly developed by American organizations and agencies such as USGS[4], NASA[5], NGIA[6], EROS[7] was made available to the entire world. However, raw data access requires their further transformation, processing, compilation and visualization using GIS tools as spatial data servers do not often have built-in webGIS (geoportal functions) tools to visualize online data (Pokojska, Pokojski 2015).

From the point of view of environmental education (including education for sustainable development), what is especially important is the access to spatial data with the possibility of visualization. In 2007, the European Union Directive INSPIRE establishing infrastructure for spatial information in the European Community was announced. Spatial data that was collected and developed under the aforementioned initiatives was summarized into three annexes covering thirty-four topics (Directive 2007). The following list contains topics that are closely related to spatial data:

- Attachment 1: coordinate reference systems, geographical grid systems, geographical names, administrative units, addresses, cadastral parcels, transport networks, hydrography, protected sites
- Attachment 2: elevation, land cover, orthoimagery, geology
- Attachment 3: population distribution, land use, area management, natural risk zones, bio-geographical regions, habitats and biotopes, species distribution, energy resources, mineral resources

As a result of the INSPIRE Directive implementation and transposition into the EU Member States law, a number of projects has been launched, such as the INSPIRE Geoportal, the national geoportals of the EU countries, the thematic geoportals of environmental institutions. The INSPIRE Geoportal, operated by the European Commission, enables to search and access spatial information provided by European government institutions. This is an Internet application that allows you to view spatial data and search sets and services provided in accordance with the INSPIRE Directive[8].

The INSPIRE initiative is linked to the *Joint Research Center*, which is involved in its implementation. Its objective is, among others, to provide scientific and technical support in implementing and monitoring of EU policies. The center consists of seven scientific institutes, among them: The Institute for Environment and Sustainability (IES). The INSPIRE activities are also linked to the work of the EU Statistical Office EUROSTAT and the European Environment Agency (EEA). The objective of the EEA is to "*provide sound, independent information on the environment for those involved in developing, adopting, implementing and evaluating environmental policy*" (European Environment Agency). The Agency provides data to assist in the implementation of various projects regarding the environment and environmental education. It publishes reports on the environment and quality of life in Europe.

3 The Importance of Information and Communication Technologies (ICT) in Education for Sustainable Development in Geography

4 USGS – United States Geological Survey

5 NASA – National Aeronautics and Space Administration

6 NGIA – National Geospatial-Intelligence Agency

7 EROS – Earth Resources Observation Systems

8 INSPIRE Geoportal: http://inspire-geoportal.ec.europa.eu

Data and Maps (64 interactive maps) is an important collection of environmental information. It allows for the analysis of water quality (28 maps), air pollution (16 maps), land use changes (7 maps), urban development (5 maps) etc.[9] The data presented on the maps can be downloaded as text or database files. Data from these published reports as well as interactive maps can be used successfully in environmental education, especially in educational projects on phenomena occurrence analysis, their spatial diversity presentation or their dynamics. For example, maps containing PM2.5 and PM10, benzo(a)pyrene and lead spatial distribution from past years can be compiled and verified with maps on the smog phenomenon published in the Polish media in mid-2017.

Over the last two decades, a number of geographic environment initiatives that can be used in environmental education have been launched in the European Union. Currently, studies developed under the *Copernicus* project are of a great importance. It is a European monitoring system that is coordinated and managed by the European Commission. The data is obtained from Earth observation satellites (under the auspices of the European Space Agency) and in situ sensors such as earth, air and marine stations (under the auspices of the European Environment Agency). The *Copernicus* program includes global projects (vegetation, water and energy circulation) European projects (the above-described *CORINE Land Cover* project, *Image Mosaics* project on high resolution satellite imagery and the *European Settlement Map* project showing settlement location and diversity) and local projects (*Urban Atlas*, *Riparian zones* and *Natura 2000*). Under the *Corine Land Cover*[10] (CLC) and *Urban Atlas* projects data on land use patterns and their changes over time have been developed and published. CLC is a project that was launched in 1985 and aims to provide up-to-date information on land cover and land use across Europe (in a regular cycle and by demonstrating changes between cycles). Since 2000, the project has been coordinated by the European Environment Agency. A coherent land cover legend was used to develop maps for the years 1990, 2000, 2006 and 2012 (CLC1990, CLC2000, CLC2006 and CLC2012, respectively) and maps showing changes in land cover between those years. The data developed in the CLC project is widely used in studies on land use and land cover changes. The *Urban Atlas* project included preparing and publishing vector spatial data on land use within functional urban areas (FUA) in Europe, updated for years 2006 and 2012. The *Riparian zones* project collected spatial data on land use in river valleys' floodplains occupied by riparian communities. This data was collected to monitor biodiversity in floodplain areas. Natura 2000 (N2K) project was designed to assess if the established Natura 2000 sites are properly protected.

Assembled data servers (projects) allow you to download raw data for further use in GIS software. The aforementioned projects' websites in the table (Table 1) offer mechanisms for viewing the processed resources in the form of interactive maps.

Organisation/ project	Data server address	Data type, usage
European Environment Agency	http://www.eea.europa.eu/data-and-maps	Data, interactive maps, indicators, publications on the environment
Copernicus	http://land.copernicus.eu	Corine Land Cover data (1990,2000,2006, 2012), high resolution satellite imagery, vector data from the Urban Atlas, Natura 2000 and Riparian zones projects
Geoportal INSPIRE	http://inspire-geoportal.ec.europa.eu/	online spatial data visualization, browsing, data sets searching
Eurostat Portal, Statistical Atlas	http://ec.europa.eu/eurostat http://ec.europa.eu/eurostat/statistical-atlas/gis/viewer/	statistical data visualization in the form of thematic maps

Table 1. Selected European spatial data sources

Source: own elaboration

Sharing data on the geographical environment in Poland

The EU Member States are beholden to implement the INSPIRE Directive and introduce the national spatial information infrastructure. *The Act on Spatial Information Infrastructure* adopted on 4 March 2010 and implemented mainly within the framework of the *Geoportal.gov.pl* project (Pokojska, Pokojski 2013) is the legal instrument transposing the INSPIRE Directive into the Polish legal system. In this act (Act ... 2010), the Minister responsible for the environment, the Chief Inspectorate of Environmental Protection, the Chief Nature Conservator and others were obligated to perform activities related to providing spatial information on the environment. As a result, several portals have been created to provide access to the spatial information; they are listed in the table (Table 2).

Spatial data resources are available in Poland though the *Geodesic and Cartographic Documentation Center* (CODGiK) [11] that publishes data on topography, alti-

9 http://www.eea.europa.eu/pl/publications#c14=&c12=&c7=pl&c11=5&b_start=0

10 CORINE- Co-ordination of Information on Environment

11 CODGiK operates until 31 December 2017. From 2018 onward its tasks will be performed by the Head Office of Geodesy and Cartography.

Name of data source/geoportal	Address	Map resources
Geoportal (national)	http://geoportal.gov.pl	topographic and thematic maps with different scales, orthophotomaps, National Register of Boundaries, cadastral data, shaded maps, General Geographic Database
Geodesic and Cartographic Documentation Center	http://codgik.gov.pl/	collecting, conducting and sharing the central geodetic and cartographic database, providing vector data from the BDOO (General Geographic Objects Database), PRG (**National Register of Boundaries)** and PRNG (National Register of Geographical Names)
GIOŚ INSPIRE	http://inspire.gios.gov.pl/portal/	nature monitoring data regarding water, air, noise, electromagnetic fields, ionizing radiation
GDOŚ	http://geoserwis.gdos.gov.pl/mapy/	range of nature protection forms, animal crossings, sozological map, hydrographic map
RDOŚ Bydgoszcz	http://geoportal.rdos-bydgoszcz.pl/	interactive maps: information layers on the values of the natural environment, forms of nature protection
RDOŚ Katowice	http://www.geoportal.rdos.katowice.pl/geoportal/	
State Forests (forest map)	http://www.lasy.gov.pl/nasze-lasy/mapa-lasow	range of forest areas, Forest Promotion Complexes, forest fire forecasts and periodic forest entry prohibitions
National Water Management Authority	*http://geoportal.kzgw.gov.pl/gpt-kzgw/catalog/main/home.page*	river basins, water regions, homogenous water bodies
Polish Geological Institute	*http://geoportal.pgi.gov.pl/portal/page/portal/PIGMainExtranet*	Central Database of Geological Data, access to downloadable data in the shp format and in the WMS and WFS standards
Tatra National Park	*geoportaltatry.pl/*	interactive maps: ranges of national parks, educational trails, terrain models, geology, hydrography, nature reserves
Karkonosze National Park	*www.gis.kpnmab.pl/*	
Biebrza National Park	*bpn.e-mapa.net/*	
Bory Tucholskie National Park	*gis.pnbt.com.pl/*	
Geostatistics Portal	*https://geo.stat.gov.pl/*	cartographic presentation of statistical data

Table 2. Selected Polish portals providing information on the geographical environment

Source: own elaboration

tude, terrain, and administrative borders. CODGIK is responsible for the national Geoportal, which provides multiple spatial data sets. The table (Table 2) also lists selected thematic geoportals prepared by various environmental protection institutions. *Geoportal GIOŚ INSPIRE* that was set up by the Chief Inspectorate of Environmental Protection provides access to nature monitoring data. In addition, the Geoportal led by the General Directorate for Environmental Protection (GDOŚ) provides access to data on forms of nature protection locations in Poland and to the Central Register of Nature Conservation Forms. There is also the National Water Management Authority geoportal, which provides access to hydrological data and Polish Geological Institute geoportal that contains geological data and groundwater resources.

The management of the regional directorates for environmental protection and national parks provides geographic information on the environment in their areas of activity on their geoportals. GUS (Central Statistical Office of Poland) has the Geostatistics Portal application – it is a modern solution that provides cartographical presentation of statistical results obtained in the censuses.

Use of spatial data in environmental education – selected examples

Downloadable spatial data that was made available through geoportals has been applied to projects in environmental education. In the sustainable development education projects (as part of geographic and biological education in school) the use of spatial data derived from various sources "*allows to capture (...) human-nature interactions that are the essence of ecological education, but also to compare phenomena and their dynamics, sizes and ranges in different spatial scales*" (Angiel et al., 2017), including areas of high educational potential such as the Vistula River Valley (Angiel, Angiel 2015, Angiel, 2010). The data obtained in the Urban Atlas project on the Vistula River valley is used during classes intended for postgraduate teachers at the University of Warsaw in the area of using the GIS techniques in teaching geography.

There is also an urbanization project in Spain which is great example of utilizing land use data. The project mentions that the results of land use change studies are of great importance for the principles of sustainable development (Gonzalez 2012). The GreenGo! Project is another example of an educational activity that includes data on land use change. The aim the project, which was carried out by GRID Warsaw was to raise awareness on the role of green infrastructure and the means for its

sustainable development in rural areas. Furthermore education programs conducted in cross-border cooperation between Poland and Germany within the Education for Sustainable Development (German-Polish experience in Education for Sustainable Development) used data and GIS tools in projects implemented by young people concerning landscape transformations in some areas with strong anthropogenic and on the distribution of nature conservation areas.

Summary

The GIS technology enables integrating information from multiple sources into one system for spatial analysis, drawing conclusions and making decision. Initiatives related to the spatial data infrastructure development (e.g. INSPIRE, indirectly the development of GIS software including webGIS) have contributed to the high demand for spatial data. "Spatial data liberation" coincided with the rapid development of web applications. Geo-archives and geoportals were developed and free license computer applications were created. Spatial data (mostly available free of charge) which is used as a source of data by the creators of these applications has played a crucial role in these opportunities emergence. Both applications and spatial data can and should be used in the broad environmental education, including sustainable development education. They enable environmental education that accounts for special phenomena, show the correlation between of the components of the geographic environment and the form, intensity and extent of human activities.

The statement on the difficulty of accessing data and GIS tools presented at the International Geographic Union conference in 2007 – that was mentioned at the beginning of this article – has become obsolete in Poland and other EU countries within only ten years.

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Knowledge about local natural monuments – ignorance or flaws of the education system?

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Summary:

The study presents the preliminary results of a survey examining knowledge about local natural monuments among students in different grades. We found that their knowledge is poor and critically needs to be improved. Since the students seem to rely mainly on the Internet and their smart devices, we propose that a type of outdoor class be held, which must be supported by multimedia. The study presented here was conducted in Zielona Góra, in 11 schools of four types or grades.

Key words: natural monuments, awareness, students, school, familiarity, Zielona Góra

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Introduction

According to Polish law, a natural monument can be a single or group of living or non-living natural objects that have uncommon traits and are valuable for nature, science, culture, history and the landscape, including native and foreign species of trees and shrubs, caves, and rocks, among others (Law on the Protection of the Natural Environment of 2004 with later amendments). This is in agreement with the definition given by the International Union for the Conservation of Nature (IUCN): „Category III – Natural Monument: protected area managed mainly for conservation of specific natural features. Area containing one or more specific natural or natural/cultural feature, which is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance" (Davey, 1998). The list of Polish natural monuments is accessible from the website of the Regional Directorate of Environmental Protection or the Central Register of Forms of Nature Conservation (http://crfop.gdos.gov.pl/CRFOP/) (acronym CRFOP). The CRFOP is a database of all forms of nature conservation existing in Poland, which provides information about them. For example, a user interested in a local natural monument can learn about the types of the monument, species, age, location, size and all other characteristic features of the given object. Additionally, CRFOP is linked to Geoserwis (http://geoserwis.gdos.gov.pl/mapy/), a map service providing information about the environment, including forms of nature conservation and the „Natura 2000" network. However, CRFOP and Geoserwis are still incomplete or have erroneous data (for example, either no or the wrong pictures of natural monuments) (Tokarska-Osyczka and Pilichowski 2016).

The legal basis for education in Poland is in the Polish Constitution. According to this document, everyone has the right to an education, and it is compulsory for every person under the age of 18. Education in public schools is also free. The Polish education system is governed by two Ministries. General and vocational education are managed by the Ministry of National Education and higher education is under the governance of the Ministry of Science and Higher Education. These two institutions are responsible only for the policies of the education system, while the administration of schools is decentralized. Pre-schools, primary schools and lower secondary schools are administered by local governments, upper secondary schools are administered by county authorities and higher education institutions are autonomous (Smoczyńska 2014).

Educating students about the environment and the forms of nature protection occurs in different grades and classes, however the common opinion of teachers is that the time spent on such issues is insufficient. According to the current core curriculum of primary school, issues on environmental protection and conservation should be covered by 4th grade students in science classes, in 7th grade in geography classes and in 8th grades in biology classes. There is also an attempt to link the content of the chemistry class with environmental issues. Hopefully, the new core curriculum will actually integrate the development of environmental attitudes with teaching. It is very important to shape the attitudes of young people due to the degradation of the environment occurring as the result of human activities. There is a hope that in the future, people will want to protect the environment and conserve biodiversity, but they need to gain an understanding of the problems during their school education.

Zielona Góra is a city located in western Poland, and is one of the two (together with Gorzów Wielkopolski) capitals of Lubuskie Voivodeship. On the first day of 2015, Zielona Góra became a larger city by fusing with another township. This fusion established two boroughs: „the City of Zielona Góra" (the city within its old

boundaries) and „New Town" (the area of the township) (Greinert and Drozdek 2015).

As Tokarska-Osyczka and Pilichowski (2016) stated, there were 53 living natural monuments in the area of Zielona Góra in its new borders. Most of the schools functioning in the city are located within less than one kilometer from a natural monument. In 2017, however, three new natural monuments were established, two lost their status due to decisions of the City Council, aimed at ensuring public safety since their condition deteriorated, and finally, one of the natural monuments collapsed due to Hurricane Xavier. Even though the number of natural monuments in Zielona Góra changed in 2017, we treated the two former natural monuments as still having the status of a natural monument because of the date of the survey study we conducted. We were interested in the overall knowledge of students about local natural monuments and thus we surveyed them by asking six questions. The aim of the study was to evaluate the understanding of the term "natural monument" among students of different ages, and to determine the extent of their familiarity with local natural monuments. We consider natural monuments as objects that are easy to observe and possessing countless educational values – starting with esthetic, landscape and tourist values and ending with environmental and ecological values. Showing such objects to students may raise their awareness and respect towards nature. According to our experiences, the overall knowledge about natural monuments among people is poor; however, we are not aware of studies concerning such issue that have been conducted with Polish students.

Materials and methods

The study was conducted from November 2016 to January 2017. The 11 schools chosen for the study (Tab. 1) were located within the borders of the „City of Zielona Góra" (we will call it "Old Zielona Góra" and we will use "New Zielona Góra" instead "New Town"). Three primary schools, four lower secondary schools, three upper secondary schools and one vocational upper secondary school responded to our request and the school directors allowed us to conduct the survey among students in the final grades of each educational level. Our aim was to include 11 schools in three parts of the city, where different natural monuments are located and where schools of at least three educational levels exist. Unfortunately, we did not receive responses from several schools and thus, we were forced to choose new schools to perform surveys.

The survey consisted of six questions examining basic knowledge of the students about natural monuments:

- Q1: What can be considered a natural monument?
- Q2: How many natural monuments are located in today's Zielona Góra?
- Q3: List five natural monuments that are located near your school and describe their approximate location.
- Q4: Would you like the teacher show you natural monuments as a part of the outdoor biology/science classes?
- Q5: Do you think that there should be more natural monuments in the city?
- Q6: Where can you check how many natural monuments can be found in the city?

The students were also asked to provide information about their sex and place of residence: in Old Zielona Góra (OZG), New Zielona Góra (NZG) (an area of former villages, now part of the city of Zielona Góra), a city with less than 100 000 inhabitants (we will call this a town) or a village.

The surveys were printed and distributed to the students. The time needed to answer the questions was about 15 minutes. The authors conducted the surveys personally in four schools, whereas teachers administered the surveys in the remaining seven schools. The school director of each school agreed to this and granted permission for conducting the survey. Since our study generated a large amount of data and we were able to categorize the answers only after obtaining the completed surveys, we decided to split the results into two parts. In this paper we will focus on questions: 1, 3 and 6, and analyze the answers of students to verify their understanding of the term „natural monument". These three questions were chosen to be analyzed together because in our opinion, they reflect the familiarity of the students with local natural monuments. The results obtained for questions 2, 4 and 5 were presented during a conference that took place in Zielona Góra, on September 19-21, 2017 (XXI Krajowa Konferencja Dydaktyków Przedmiotów Przyrodniczych, University of Zielona Góra) and will be published in a separate paper.

The responses provided by the students were analyzed in relationship to educational level and sex. If the analyses showed no differences, the data were analyzed without discriminating between the type of school or sex. JMP 11.2.0 SAS Institute Inc. software was used for the statistical analyses.

Results

In total, 601 students answered the survey: 283 females, 286 males and 32 unidentified students. Most of them inhabited Old Zielona Góra (286). 90 lived in New Zielona Góra, 61 in towns, 94 in villages and 70 did not indicate their place of residence (Table 1).

Question 1. What can be considered a natural monument?

The students usually listed objects that may be considered natural monuments. 62 students (10.32%) did not answer this question or wrote „I don't know". 315

students (52.41%) named or described one object, while 159 students (26.46%) two, 56 students (9.32%) three, 7 (1.16%) four, one student (0.17%) five and finally one student (0.17%) named or described six objects which could be a natural monument (Fig. 1). The answers were grouped into nine categories as follows: I. Trees, II. Nonliving elements of nature, III. Other natural objects, IV. Parks and other urban green spaces, V. Man-made objects, VI. Unidentified, VII. Animals, VIII. Definitions, IX. Other. Examples of answers representing all nine categories are showed in Table 2. Eight students from one upper secondary school answered the question almost or perfectly by writing a definition of the natural monument (category VIII). The comparison of percentage of answers belonging to all categories among school levels is shown in Fig. 2. The most common answers were „tree" and similar (an old tree, a special tree, an oak, etc.): PS 47%, LS 46%, US 37% and VS 53%. Second, categories II and III taken together constituted respectively 37%, 26%, 41% and 37% of all answers. One tenth of students in lower secondary and upper secondary schools did not know how to answer this question (category IX). After excluding from the statistical analysis answers of students who did not indicate their sex, a contingency table was produced to search for relationships between sex and the number of answers provided by students (Table 3). The number of answers was treated as the nominal value. The results show that some differences exist between female and male students, especially in the categories of 3 and 4 answers (35 to 18 and 6 to 1 answers given by girls and boys respectively). Educational level had no impact on the number of answers.

Question 3. List five natural monuments which are located near your school and describe their approximate location.

Table 2. Examples of answers to the first question

The description of the categories is provided in the text.

I	an oak, the oak „Bartek", a tree, a tree with a historical value, a group of trees
II	a stone, a rock, a lake, nonliving nature, a river
III	a valley, old plants, a nature's work, an element of nature, plants, a grass, rare plants, an old bush
IV	a garden, a park, the „Piastowski" Park
V	a former building, monuments, an avenue, a landmark building, a statue, old buildings
VI	a very old object, interesting objects, a place, nature before extinction, old natural monuments
VII	an animal in nature, animals
VI	*Eight answers were classified as definitions of a natural monument. See the text for details.*
IX	I don't know, almost everything, everything, everything if you want

Table 3. Contingency table showing the distribution of the number of answers to question 1 with differences between female and male students

To generate the table, the number of answers was treated as the nominal value. Data generated by students who did not indicate their sex were excluded from the analysis.

Count Total % Col % Row %	0	1	2	3	4	5	6	Sum:
female	21 3,69 36,84 7,42	143 25,13 47,35 50,53	77 13,53 52,03 27,21	35 6,15 66,04 12,37	6 1,05 85,71 2,12	1 0,18 100,00 0,35	0 0,00 0,00 0,00	283 49,74
male	36 6,33 63,16 12,59	159 27,94 52,65 55,59	71 12,48 47,97 24,83	18 3,16 33,96 6,29	1 0,18 14,29 0,35	0 0,00 0,00 0,00	1 0,18 100,00 0,35	286 50,26
Sum:	57 10,02	302 53,08	148 26,01	53 9,31	7 1,23	1 0,18	1 0,18	569

N	DF	-LogLike	RSquare (U)
569	6	8,6776192	0,0126

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	17,355	0,0081*
Pearson	16,047	0,0135*

In this question, students were asked to list five natural monuments located near their school and to describe their approximate location. This question generated a large amount of data. Among the answers, we found correct ones, almost correct ones (showing that a student possesses knowledge about some natural monuments but needs to clarify it), wrong answers and comments "I do not care").

To analyze the percentage of answers classified within various categories, we did not include 8 persons who answered "I do not care". Since we asked students to list five objects, we aimed to obtain 3005 answers (5*601 students), however after ignoring "I do not care" answers, we had 2965 answers (3005-8*5). It is striking that we obtained 2597 answers (88%) of "I don't know" or left blank (Table 4). Correct answers constituted 3% of all answers, similarly – almost correct (3%), while

	PS	SS	US	Tech	SUM
Correct	31 (4%)	38 (4%)	8 (1%)	4 (1%)	81 (3%)
Almost correct	10 (1%)	26 (3%)	31 (4%)	12 (3%)	79 (3%)
Wrong	44 (6%)	86 (9%)	30 (4%)	48 (10%)	207 (7%)
I don't know	660 (89%)	830 (85%)	691 (91%)	416 (86%)	2597 (88%)
Total number of answers:					2965
I do not care	0	1	0	7	8

Table 4. The table shows the structure of the answers obtained to question 3 (*List five natural monuments which are located near your school and describe their approximate location*)

Numbers of answers and percentages (in parentheses) of the total are presented. The fifth category of "I do not care" is not included in the data set (see text for details).

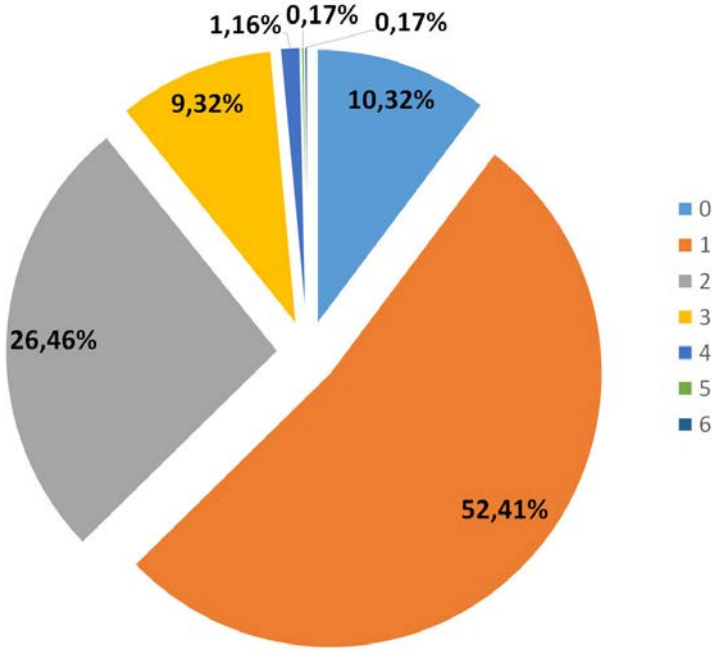

Fig.1. The number of examples of objects that may be natural monuments (0-6) presented as percentages of the total sum of answers to question 1

For example: 52.41% of surveyed students listed only one object that could be a natural monument and 9.32% listed three various objects.

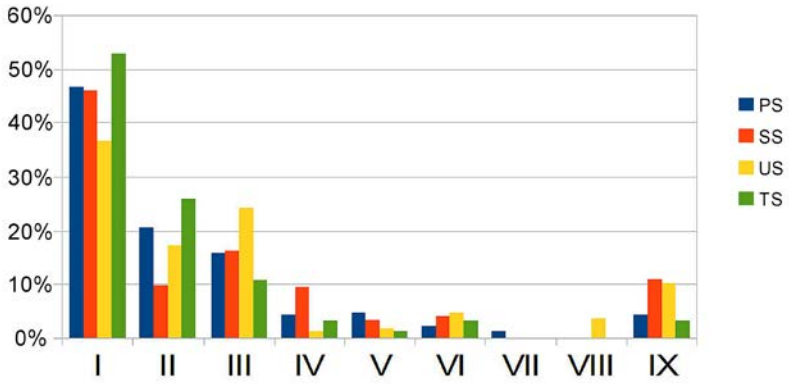

Fig. 2. Percentage of answers to question 1, representing various categories, grouped by educational stage. PS – primary school, LS – lower secondary school, US – upper secondary school, VS – vocational upper secondary school

Categories I-IX are explained in the text. Number of students: PS 149, LS 197, US 152, VS 103. The figure illustrates the total percentage of answers – the number of answers (901) was higher than the number of students since surveyed students proposed none, one or up to six objects which could be a natural monument.

7% gave wrong answers. Examples elucidating the categories are provided in Table 5. Correct answers were acknowledged all those indicating natural monuments found in Zielona Góra, independently of the distance between the school and the object. The categorical response analysis performed in JMP 11.2.0 (SAS Institute) showed that the frequency counts of answers within populations (educational levels) are homogenous.

Question 6. Where can you check how many natural monuments can be found in the city?

In this question, students were asked to write where information about the number of natural monuments of Zielona Góra can be found. We decided to group answers into ten categories (Table 6). 601 students provided 886 sources of information. 53% (475) of the answers belonged to category VI, with 450 answers „in the Internet". 130 (15%) answers were classified in category IX (various media, press, publications) where „books" were the most common answer (48; 5% of the total). A comparison of the percentages of grouped answers is presented in Fig. 3.

Discussion

Students' knowledge about natural monuments was assessed as poor. They were barely able to name objects which could be a natural monument, rarely knew its definition and could not identify precisely where information could be found about the number of natural monuments existing in Zielona Góra. What is really concerning is that there are, in general, no differences between educational levels, sex and place of residence in relation to the answers provided, however, female students listed 3 or 4 objects that can be considered natural monuments more often than boys (Table 3). We presume that this general lack of differences is the

Correct	1) The beech tree growing in the Piastowski Park. 2) The yew trees growing next to the Post Office on Sienkiewicz Street.	The object and location are correct.
Almost correct	1) The yew tree growing on Kupiecka Street. 2) A tree growing next to the Church of the Holiest Savior.	1') The tree is growing on Kopernika Street, which is next one to Kupiecka Street. 2') There are a few natural monuments near the church.
Wrong	1) A forest next to the High School number 4. 2) The Piastowski Park. 3) <something> next to Nursery School No. 27. 4) The botanical garden. 5) The oak tree.	1') The object and location are wrong. 2') Parks and forests are not natural monuments. 3') There is no natural monument close to Nursery School No. 27. 4') The botanical garden is not a natural monument and there are no natural monuments there. 5') Insufficient answer.

Table 5. *Examples* of answers to question 3, which were classified in three categories: correct, almost correct and wrong.

Category	Examples
I. Public administration, agencies	The city website, City Hall, the township office
II. Foresters	The website of the State Forests, foresters
III. School	School books, school lessons, a teacher, school
IV. Tourism	A tourist information centre, a city map, a book about Zielona Góra, excursions, sightseeing
V. Family, people from surroundings	Adults, grandmother, citizens, family, parents
VI. Internet and devices	The Internet, Google, the city website, smartphone, Facebook
VII. Materials and reports about natural monuments	Conservation Office, registers of natural monuments, special maps, the city website about natural monuments, labels on protected objects, publications about natural monuments
VIII. University, specialists	A library, the local University, botanical garden employees, botanists, biologists
IX. Media (press, radio, TV, publications other than in VII.)	By reading, journals, an encyclopedia, a nature atlas, books about nature, press, TV, maps
X. Others	"I don't know", from life

Table 6. Sources of information about the number of natural monuments listed by the surveyed students and classified in the presented categories.

result of several factors: 1) Lack of outdoor lessons with teachers; 2) Lack of time spent outdoors with family and friends; 3) Insufficient marking of natural monuments by City Hall; 4) Poor information campaign – unclear sources of information for students; 5) Not enough time in the core curriculum devoted to issues concerning nature protection; 6) Limited knowledge of teachers about local natural monuments. Fig. 4 shows the location of schools participating in the survey (1, 2, 3 – primary schools; 4, 5, 6, 7 – lower secondary schools; 8, 9, 10 – upper secondary schools; 11 – vocational upper secondary school) and natural monuments within borders of Old Zielona Góra (triangle – a living natural monument; circle – a non-living natural monument). The circles around schools indicate a distance of 0.5 km (the diameter equals 1 km), so it can be clearly seen that each school is able to organize an outdoor activity and visit at least one natural monument during the time of a regular lesson. The core curriculum obliges teachers to teach about forms of conservation, including natural monuments, in early education classes, science classes, biology classes and geography classes in primary school (current core curriculum). During the secondary stage of education, pupils are taught various issues in biology classes, however, there is too little time spent on environmental issues and the conservation of biodiversity. Thus, the knowledge of Polish pupils and students about nature is poor (The State Council for Nature Conservation 2016, Zawada 2016). As Falkiewicz-Szult (2014) wrote „It is worth mentioning that the leading role in the environmental education of children is played by a teacher" and it is up to teachers to organize the educational process and stimulate the curiosity of students and awaken their sensibility towards nature. Of course, teachers must be supported by the education system, school equipment, school environment, parents and students (Baker et al. 2002). Also, teachers should be encouraged to organize outdoor lessons, since they may fear going outside and encountering many questions from their students (Dillon et al. 2006). Moreover, they may be concerned about health, safety and the fears of their students (Dillon et al. 2006), which cannot be ignored, since students can behave unpredictably. We consider it alarming that pupils of all school levels find it difficult to define a natural monument. In fact, most of them described it correctly as a tree (Fig. 2, category I). Some of the students defined it as non-living objects (rocks, waterfalls) which is promising, because they understand that not only trees and other living objects of nature can be considered natural monuments. Nonetheless, they listed monuments, buildings, parks, statues and animals as such objects. Fig. 1 presents how students imagine natural monuments – they mostly see them as a single-type object, even though we expected the students to list several objects or provide a definition. Unfortunately, we were positively impressed only with eight answers of students from a particular upper secondary school. These were valuable definitions of a natural monument, for example: „a priceless object of nature, important for scientific, historic and cultural reasons" or „a specific object of nature – living or non-living – which is special (because of age, rarity)". We suspect that this task would be easier for pupils who have outdoor classes and visit nearby natural monuments, since environmental education can be positively influenced by visiting green spaces (Wolsink 2016).

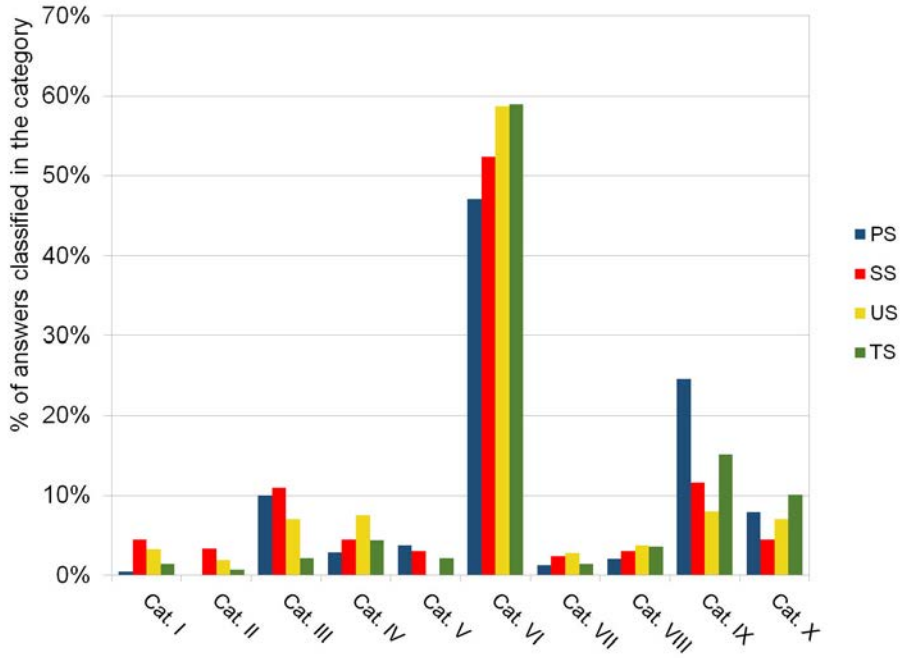

Fig. 3. Percentage of answers to question 6 classified in ten categories

Different colors indicate four levels of education: PS – primary school, LS – lower secondary school, US – upper secondary school, Voc – vocational upper secondary school.

Since the majority of the natural monuments found in Zielona Góra are trees, they can play a great role in teaching dendrology in addition to environmental issues. Linking both aspects (teaching dendrology and environmental protection) in a single outdoor class increases the chance of shaping environmental attitudes. The ultimate question is how to awaken and strengthen respect towards nature. In our opinion, the most important aspect is showing students biodiversity, starting with local examples of common and rare organisms and their relationships. The monument trees in Zielona Góra are commonly inhabited by ants, sometimes they are infected with fungi or house xylophagous species and birds. Those trees are usually much taller and have wider trunks than other trees in the neighborhood. Moreover, they manifest species-specific capabilities, starting with flowering and fruition to reaching a respectful size and age in the end. The rarity of similar trees occurring in urban spaces, agricultural landscapes and forests well serves as proof of the progressing negative impact of humans on the environment. The revised Nature Conservation Act and changes to the Forest Act, which came into force on 1 January 2017, partially lifted the requirement for a permit to cut trees or bushes. Private landlords were able to remove trees or shrubs on their property without permission unless these objects were natural monuments. Similarly, cutting down trees and bushes to restore land to agricultural use did not require permission as well. Fortunately, after few months, the Nature Conservation Act was amended and removing trees from private land without permission is prohibited once again.

No one, however, is able to provide reliable statistics showing how many trees were removed from private properties, but by observing our own neighborhoods, the scale of the cut is huge. Not only did single trees disappear, but whole squares and rows of trees. Due to these changes, an enormous number of trees were removed from the landscape, which may result in the future in an important age gap between current monument trees and young ones. No one can exclude that after removing old trees, there will be any candidates of appropriate size and age to become new natural monuments.

Carmi et al. (2015) see the complexity of environmental issues and compare them to a vast forest where each tree is different and requires an individual approach. This may be true, nonetheless, a single object, such as a natural monument, exhibits individual traits and problems which can be extended to other similar objects, including those existing in the non-urban environment. Probably environmentalism and biology courses are examples of the few domains that must be taught in accordance with a core curriculum that includes contact with nature. So they should not, or even must not be dominated by new technologies, rather they should cooperate with them. In Appendix I, we propose a form of outdoor activity that includes visiting a natural monument. This approach provides the opportunity to conduct a lesson and have the students gain new experiences based on using various senses. This is for the benefit of both the teacher and students, since being active supports memorizing (Chawla 1999), working in groups and social development, also, the relationship between a teacher and students may improve (Barker et al. 2002, Męczkowska & Rychterówna 1923) As Męczkowska and Rychterówna (1923) wrote almost a century ago: „Conversations between a teacher and students during a walk should not be limited only to environmental issues. Indeed, a teacher is supposed to talk with students about off-topic subjects to make the outdoor lesson more friendly".

Today, students expect to find any information they need in the Internet by using their smart devices (smartphones, tablets, etc.) or computers (Fig. 3.). This issue should not be ignored. Schools and the education system have to adapt to this and design new methods of teaching and providing knowledge to meet the expectations of students and keep up with the era of digital technology. We do not mean to replace handwriting, reasoning and many other skills with devices. We simply encourage teachers to let students use their smartphones in class or during outdoor activities to achieve learning goals. Such information, as the number and detailed parameters of natural monuments, should be clear and easy to find in the Internet. We presume that if teachers could easily obtain the proper information, they would eagerly share it with students. The second source of information listed by students were various media (e.g. TV, radio, press) (Fig. 3.). Using the Internet and other media as a source of knowledge is unavoidable. However, teachers should emphasize the value of other sources that do not require electricity and are listed in Table 5. According to Polish law, a natural monument has to be properly labelled to inform everyone that a given object is protected and is valuable for a variety of reasons. Unfortunately, some natural monuments in Poland, including in the Zielona Góra area (Tokarska-Osyczka and Pilichowski 2016), have no labels of their status, which is a negligence of the local governors. Similarly, the CRFOP commonly lacks significant data (such as species, trunk diameter, age), making this register useless in many cases. Furthermore, the Geoserwis is incomplete and does not show the positions of some natural monuments on the map, especially those recently established (Tokarska-Osyczka and Pilichowski 2016). In the opinion of The State Council for Nature Conservation (2016), the system of gathering and providing information about conservation issues should be drastically improved. It is challenging to offer to children and youth an attractive presentation of natural monuments and other natural objects, then draw their

attention to these objects and make them understand the importance of respecting nature. So, in our opinion, public information systems should be designed not only to provide basic information, but also to supplement this with original materials, for example, infographics, podcasts and stories connected to natural objects, national parks, etc. It is worth considering producing infographics with students after visiting natural monuments and publishing them on the Internet. The use of infographics improves teaching (Alshehri and Ebaid 2016) and is interesting for students (Kos and Sims 2014). By using innovative methods of teaching, students' achievements can be improved (Cachia et al. 2010, Fidelis 2017), together with their scientific understanding and reasoning (van den Broek 2012).

Coclusions

Knowledge about local natural monuments among surveyed pupils is very poor. Furthermore, they have a weak understanding of what can be protected as a natural monument. In general, such knowledge does not differ between the four studied educational levels and between male and females students.

Internet is a promising source of that knowledge, however, it does not offer sufficient and clearly accessible data. Local governors should think of designing an interesting and attractive website concerning natural monuments and other forms of conservation.

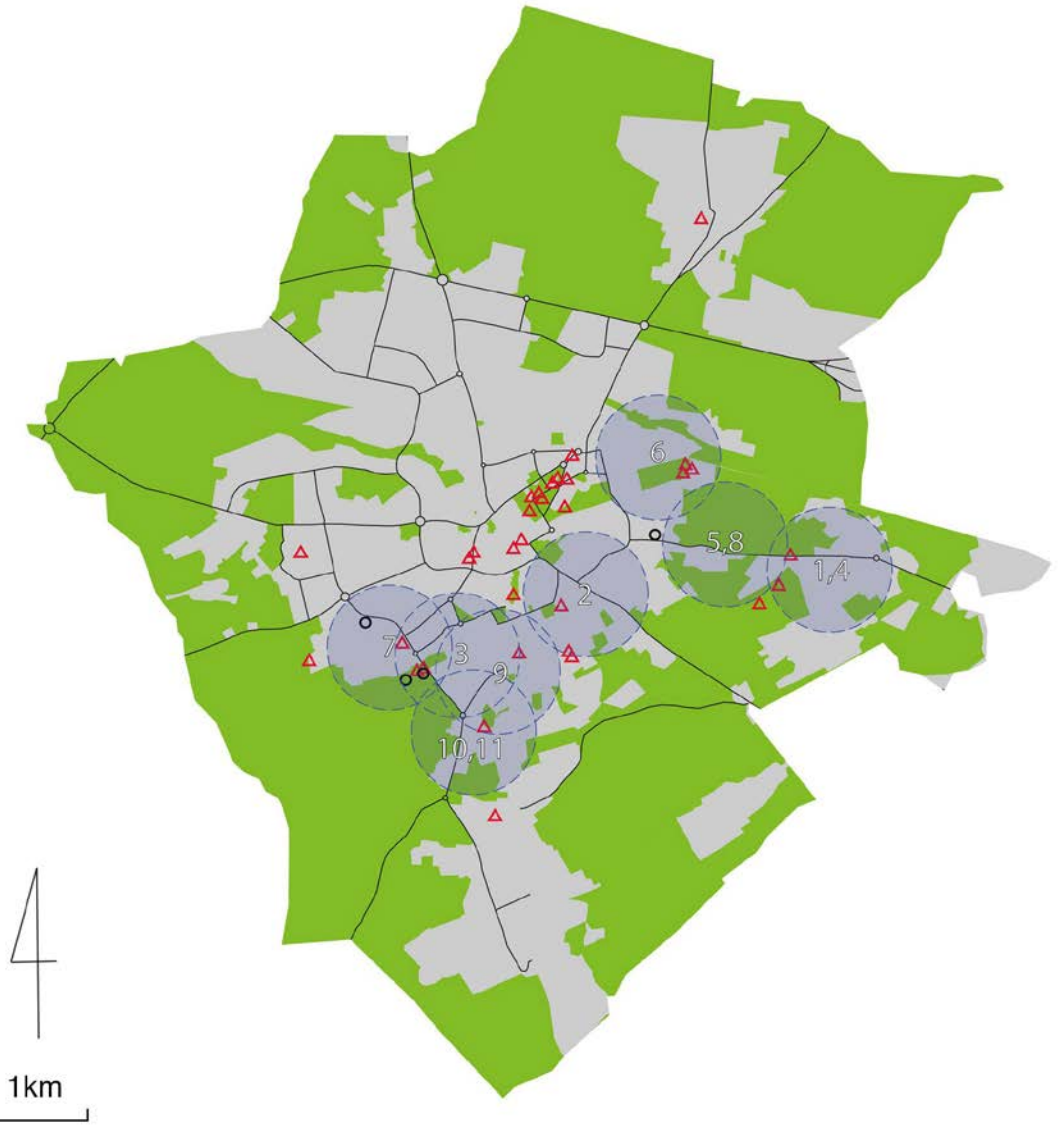

Fig. 4. The map shows Old Zielona Góra (OZG), the surveyed schools and all natural monuments occurring within the OZG borders

Living natural monuments are marked by red triangles and non-living natural monuments by black circles. The numbers 1-11 indicate the surveyed schools and the area surrounding the schools was marked by a diameter equal to 1 km.

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Appendix I. Exercises for students (ISCED level 1, 2A, 3A)

Take a photograph of a natural monument you visited during the outdoor class. Pay attention to its appearance, its condition, especially damage and to the organisms inhabiting it. Note all your observations. Take photographs of details, e.g. leaves, fruits, holes in the tree trunk, lichens, mosses, insects crawling on its surface. If you observe a tree, you can measure its girth at breast height (1.3 m from ground level). In the case of rocks – you can measure their height and width. If possible, find trees of the same species in the neighborhood and also measure their girth at breast height. Compare the measured girths with the natural monument. To measure tree height, you do not need advanced tools. Ask your colleague to stand next to the tree. Walk out so you can see the whole tree – the top and the base – without moving your head. Remember to stand at the same ground level as the tree. Take a photograph of the tree and your colleague standing next to it. Measure your friend's height and estimate the tree height in the photograph.

Find information about the visited natural monument in the Internet. Did you find it easily? Was the information you found clear and detailed? Would you like to change/add something?

Create an infographic about natural monuments. As an illustration and example, use the natural monument you visited during the outdoor class. Describe your work to your colleagues. See the exemplary infographic in Appendix II.

Appendix II. An exemplary infographic

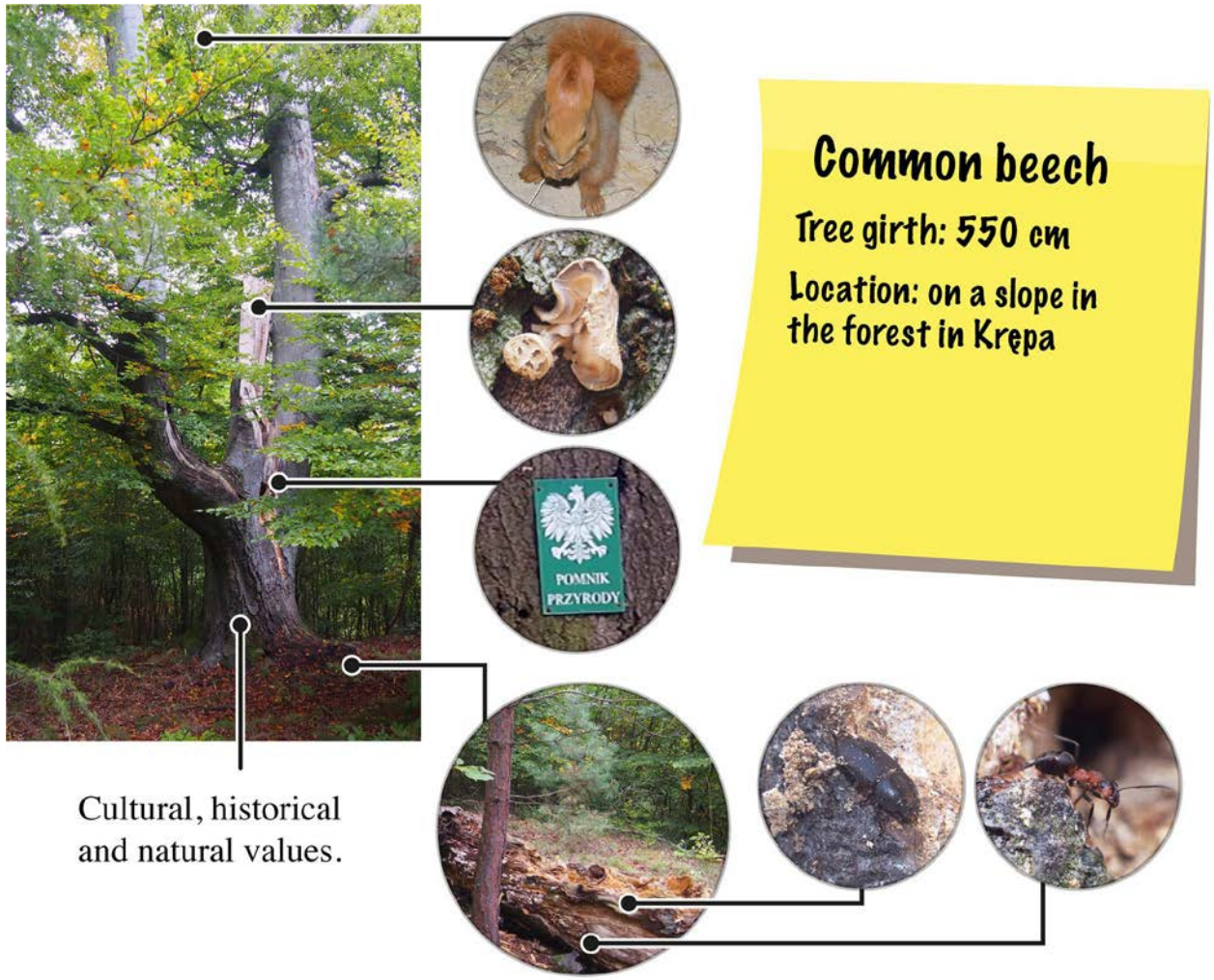

Fig. 5. The exemplary infographic shows a natural monument – a common beech tree growing in Krępa, which is part of Zielona Góra

The tree has a variety of traits that can be observed by students, for example seeds which can be eaten by squirrels, a proper sign on the trunk, fungi present on the rotten wood, as well as a third trunk lying on the ground and inhabited by ants. Students can also measure the circumference of the tree at breast height.

Appendix III. WebQuest – Natural monuments in Zielona Góra (ISCED level 2A, 3A).

1. Introduction

According to Polish law, a natural monument can be a single or a group of living or non-living natural objects that have uncommon features, valuable for nature, science, culture, history and the landscape, including native and foreign species of trees and shrubs, caves, rocks and other things.

Do you know how many natural monuments are in your neighborhood?

After these exercises you will know. Well, do it!

2. Tasks. Part I

Group 1

1. Use the Register of Natural Monuments of the Lubuskie Voivodeship, write down the number of living natural monuments in Lubuskie Voivodeship.
2. Look at the map available at the Geoserwis map service, write down how many natural monuments there are near your school. What are they?
3. Choose five living natural monuments in Zielona Góra from among those listed in the Register. Then use the Geoserwis map service, find them and compare their location with Google Maps. Write down the coordinates of the chosen natural monuments.
4. Save all your results in a spreadsheet program (e.g. MS Excel).

Group 2

1. Use the Register of Natural Monuments of the Lubuskie Voivodeship, write down the number of

non-living natural monuments in Lubuskie Voivodeship,
2. Look at the map available at the Geoserwis map service, write down how many natural monuments there are near your school. What are they?
3. Choose five non-living natural monuments in Zielona Góra from among those listed in the Register. Then use the Geoserwis map service, find them and compare their location with Google Maps. Write down the coordinates of the chosen natural monuments.
4. Save all your results in a spreadsheet program (e.g. MS Excel).

Group 3

1. Use the Register of Natural Monuments of the Lubuskie Voivodeship, write down the number of living natural monuments in Zielona Góra.
2. Look at the map available at the Geoserwis map service, write down how many natural monuments there are near your school. What are they?
3. Choose five random natural monuments in Zielona Góra from among those listed in the Register. Then use the Geoserwis map service, find them and compare their location with Google Maps. Write down the coordinates of the chosen natural monuments.
4. Save all your results in a spreadsheet program (e.g. MS Excel).

Group 4

1. Use the Register of Natural Monuments of the Lubuskie Voivodeship, write down the number of non-living natural monuments in Zielona Góra.
2. Look at the map available at the Geoserwis map service, write down how many natural monuments there are near your school. What are they?
3. Choose five random natural monuments in Zielona Góra from among those listed in the Register. Then use the Geoserwis map service, find them and compare their location with Google Maps. Write down the coordinates of the chosen natural monuments.
4. Save all your results in a spreadsheet program (e.g. MS Excel).

3. Tasks. Part II

Use the data saved in the spreadsheet program file and count the ratio of the number of living and non-living natural monuments in Zielona Gora to the number of living and non-living natural monuments registered in the Lubuskie Voivodeship, respectively, as well as to the total number of natural monuments registered in the Lubuskie Voivodeship. Express these relationships as percentage ratios.

Produce a pie chart that will show the ratio between the counts of living and non-living natural monuments registered in the Lubuskie Voivodeship and in Zielona Góra. Compare them and comment.

4. Step by step

Task 1 (all groups)

a) Start with: http://bip.gorzow.rdos.gov.pl/inne-rejestry-publiczne.
b) Download the Register of Natural Monuments of the Lubuskie Voivodeship.
c) Open the file and look for the information you need.
d) Open a spreadsheet program file and save the results of your work.

Task 2

a) Start with: http://geoserwis.gdos.gov.pl
b) Find the menu in the top right corner and switch the map mode to the Google orthophotomap.
c) Then select the option „natural monuments" (*pomniki przyrody*) from the menu on the right.
d) Scroll the mouse to zoom in and locate Zielona Góra, then find your school.
e) Count the number of natural monuments in the neighborhood of your school.
f) If you want to obtain detailed information about a chosen object (e.g. natural monument) click with the mouse on the letter „i" in the menu on the left. Then click on the object.
g) Write and save the results in the spreadsheet program.

Task 3 (all groups)

a) Open the Register that you downloaded in Task 1.
b) Choose five objects according to the task you were given.
c) Find them in the Geoserwis map service (look at the Task 2).
d) Open the Google Maps website and find the objects you have already found in Geoserwis.
e) When you find the locations of the chosen natural monuments, click on them with the left mouse button. You will see coordinates expressed as Decimal Degrees (DD) at the bottom of the map. To obtain coordinates in the DMS system (Degrees Minutes Seconds) click on the DD coordinates – the DMS coordinates will be shown on the left.

5. Sources

- http://bip.gorzow.rdos.gov.pl/inne-rejestry-publiczne
- http://geoserwis.gdos.gov.pl
- http://crfop.gdos.gov.pl

6. Evaluation and the role of the teacher

Before giving the tasks to the students, the teacher must learn how to use Geoserwis. The teacher should also be familiar with Google Maps and the configuration of the Register of Natural Monuments of the Lubuskie Voivodeship. Otherwise it will be difficult to help students and obtain the expected results. Since the tasks presented here may be difficult for students, especially young ones, the teacher should pay attention to the effort made by students to solve the tasks. Only students who refuse to take part in WebQuest may be rebuked, however, since WebQuest is designed to develop skills and increase the knowledge of students; they should be encouraged to participate. It is advised for the teacher to prepare some type of reward for taking part in WebQuest and solving the tasks.

7. Summary

The goals of the tasks are as follows: 1) using digital technologies to find information, 2) increasing awareness of the natural monuments existing in the neighborhood and region, 3) inducing curiosity about interesting natural objects, 4) increasing knowledge about sources of information on natural monuments and other forms of nature protection, 5) social development of students working in groups, 6) diversifying teaching methods.

Elements of health education in science coursebooks

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Summary:

Preamble to Core Curriculum of General Education for Gymnasia and Post-Gymnasium Schools provides a really important statement concerning health education: (…) health education is an important task of schools on 3rd and 4th educational stages. Its goal is to develop an attitude of care for one's own and other people's health and an ability to create a health-friendly environment. The health education is not an individual part of general teaching, thus its contents are included into curriculum of other subjects, especially to science and biology, but not only to science-related subjects). The core curriculum is a foundation not only to build documents connected with didactical planning, but also especially with process of teaching. Additionally all the coursebooks used in school have to be strictly related to goals of education and teaching content written in curriculum and must be approved by the Ministry of Education. The aim of research was to investigate the level of health education contents (included in science core curriculum for classes: 4th to 6th) implementation in all science school books for ISCED 1 to check whether the teaching contents referring to the health education are compatible to the new core curriculum and if it may lead to shaping of the students' health awareness. What is important – the analyse was not aimed at making any ranking of textbooks or choosing the best one.

Key words: science, biology, coursebook, health education, core curriculum, health awareness

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From a social point of view, it is desirable that existing knowledge on health was adequately utilized, contributing to shaping healthy behaviour among the population. The mere dissemination of knowledge is not sufficient, since the use of it on a daily basis depends on many other factors, in which human attitudes play a significant role. These, in turn, depend on the emotional involvement that results from the position of health in one's hierarchy of values and the sense of responsibility for one's destiny. In a word, there must be an adequate level of motivation to maintain a healthy lifestyle. In addition, the ability to make changes in our lifestyles, adaptability, plays a big role. This feature generally develops as education level increases (Kirschner, 1992)

Health and health education in the curriculum of science and biology

Adolescence is divided into two phases: early, between 10 and 16 years of age, and late, between 17 and 22/24 (Oleszkowicz, 2011). At this time, especially during the early phase, the views, attitudes, habits and health behaviours are formed and then persisted (late stage) (Grysztar and Duplag, 2016). One of the aims of health education is to shape the health awareness of the youth. First few years of early adolescence correspond with pupils in grades 4 to 6 of primary school. In the current educational system, science subjects are integrated at this stage of learning. In the new system, which is to come into force in September 2017, science will be taught in grade 4, and then separate subjects will be gradually introduced of the curriculum – biology and geography first, then physics, and finally, in grade 7 – chemistry (MEN, 2017). The elements of health education are included in the core curriculum starting with early school education. In the second stage of training (i.e. in grades 4-6) these requirements are listed in: physical education, science and health classes. They also appear in the following subjects: modern language, Polish, ethics, practical and technical classes, computer classes and music (Woynarowska, 2009). In the preamble of the current core curriculum for primary, lower secondary and secondary schools, the following sentence is included: *Health education is also an important task of the school, carried out by teachers of many subjects, aiming at shaping the students' ability to care for their own health and the health of other people* (MEN 2009). This is a statement of essential importance. It gives a high value to health education among the school's tasks.

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Present vs. future curricula – core 2009 and 2017 curricula

Current curriculum

In the current core curriculum of general education for the secondary phase of the science subject (MEN, 2009), health education appears in four paragraphs and in a number of sub-paragraphs listed in Table 1.

No.	the content of the record
1. Me and my surroundings. Student:	
1	lists positive and negative influences on his or her well-being at school and at home and proposes ways to eliminate the negative ones;
2	explains the importance of rest (including sleep), nutrition and physical activity in the proper functioning of the body;
3	mentions the principles of proper learning and applies them in their life;
4	correctly describes a properly designed learning space for a primary school pupil;
5	explains the need for introducing day and week activity schedules; properly arranges and executes his or her schedule during the day;
6	(...) applies safety rules during science observation;
9	recognizes and names certain plants (including potted plants) that contain substances that are poisonous or harmful to humans and provides the rules for dealing with them
5. Man and the environment. Student:	
5	provides examples of positive and negative impacts the environmental has on human health;
9. Health and health care. Student:	
1	gives examples of the negative impact of selected species of animals, plants, fungi, bacteria and viruses on human health, lists behaviour to prevent and transmit diseases;
2	lists the rules for handling food products from the time of purchase to the time of consumption (expiration date, storage, meal preparation);
3	lists the principles of proper nutrition and applies them;
4	gives and applies the rules of proper care of your own body (skin, hair, teeth, nails and clothing hygiene);
5	characterizes the basic principles of sight and hearing protection;
6	explains the importance of movement and physical exercise in maintaining health;
7	gives examples of proper leisure activities, taking into account the safety rules during active games including traffic rules.
8	describes first aid in certain injuries (bruises, sprains, cuts, fractures, bites, stings), can call for help in various situations;
9	provides examples of behaviours and situations that could endanger human health and life (e.g. unexploded ordnance and dud, fire, traffic accident, skating or swimming in unauthorised places);
10	explains the meaning of the symbols placed on cleaning product containers etc. and uses the products according to their intended use;
11	lists the basic principles of safety at home, including the use of electrical appliances, the use of gas, water;
12	explains the negative impact of alcohol, nicotine and psychoactive substances on human health, provides suggestions for assertive respond in the event of peer pressures;
13	lists the principles of healthy lifestyle and explains the need to use them;
10. Electrical and magnetic phenomena in science. Student:	
4	describes the effects of current flow in household electrical appliances; describes and applies principles of safe handling of electrical appliances;

Table 1: Detailed objectives of health education as covered by the science subject in the second stage of education in the current curriculum

Upcoming curriculum

Section introducing basics. Learning objectives

The upcoming (applicable for the 4th and 7th grades of the primary school from 1 September 2017) curriculum proposed a slightly different approach to health education. In the 14 February 2017 curriculum, the preamble states: *Health education plays an important role in educating and upbringing primary school pupils. The purpose of the school is to develop students' healthy attitudes, including their introduction to hygienic behaviours that are safe for their own and others' health, and to further their knowledge of proper nutrition, physical activity and prevention* (MEN 2017). Furthermore, the chapter *Science*[1] provides the following description of the general educational objectives: During Science classes, both in the field and in the classroom, students perfect their abilities, under the guidance of the teacher, to respond properly in the event of contact with life and health-threatening organisms. These important issues concerning the structure and hygiene of the human body and its proper care shape the student 's correct behaviour in everyday life [2,3].

1 The *Biology* chapter states: *Health is at the utmost importance of biology teaching, hence the issues related to anatomy, physiology and health protection in the core curriculum for elementary education*. (MEN, 2017).

2 The chapter on *Education for Safety*: *First aid is one of the most important skills pupils learn in school. The following health and life safety issues should be addressed at an early stage of education: safety assessment of the site, identification of potential life-threatening symptoms based on simple symptoms, effective call for help, pre-medical life-saving measures* (MEN, 2017).

3 An interesting insight related to health education found in the *Physical Education* subsection: *In the core curriculum for primary education, there is a personalistic concept of education and a concept of physical fitness oriented towards health* (MEN 2017).

Introduction. Student achievements

The upcoming core curriculum describes the so-called student's achievement in the field of natural sciences (Section IV). Health education achievements are listed below.

2. Achievements in human life functions, health, safety and rest. Student:
   1. presents the characteristics of selected professions and occupations of people known from the place of residence and professions of public utility: (...) physician, nurse (…), and understands the essence of medical (...) service work;
   2. uses emergency telephone numbers, formulates a message – a call for help: Police, Emergency Medical Services, Fire Brigade;
   3. presents personal data during a contact with uniformed and medical services, in health and life-threatening situations;
   4. takes care of the hygiene and aesthetics of the their own and their surroundings;
   5. reacts appropriately in the event of a threat to their or others' safety or health
   6. lists the nutritional values of food products; is aware of the importance of adequate diets to maintain health, reduces the consumption of low-nutrient and unhealthy foods, is modest in eating sweetened products, knows the consequences of eating excessively;
   7. prepares meals that maintain health;
   8. dresses appropriately for weather conditions, looks for weather information, e.g. using the Internet;
   11. is aware of the natural hazards, e.g. sudden changes in weather, hurricanes, torrential rains, storms, droughts and their consequences: flood, fire, lightning; identifies appropriate responses in such situations;

Learning objectives in the course of science for the fourth grade of primary school

General learning objectives regarding health education: Listed below.

1. In terms of knowledge – none
2. In terms of skills and knowledge application:
   - Use of acquired knowledge of own body structure and hygiene in everyday life.
   - Applying principles of care for own health, including disease prevention
3. In the field of shaping attitudes – upbringing:
   - Proper response in life and health-threatening situations.
   - Improving the ability of care for one's body and surroundings

Learning objectives in the course of biology for grades 5 to 8 of primary school

The learning objectives for the course of biology were formulated according a different system than the one used for science. They are divided (as in the current curriculum) into general objectives – learning objectives and specific objectives – teaching content. The elements of health education are presented in Chapter V of the learning objectives:

V. Knowledge of human health determinants. Student:
   1) analyses the relationship between their behaviour and their health and recognizes situations requiring medical attention;
   2) explains the importance of blood donations and organ transplants.

Course content for 4 grade science and 5 to 8 grade biology education for elementary school

The teaching content previously included in the curriculum of the subject of science regarding the elements of health education, were divided into several stages (Table 2). It may seem that the number of records is much higher, but keep in mind that the material from junior high school is also included in grades 7 and 8. In carrying out the core curriculum in biology, *we recommend (…) the following content and requirements: 1) Grade 5: Section I and Part of the Section II (paragraphs 1-6); 2) Grade 6: Part of the Section II, (Section II paragraph 7); 3) Grade 7: Section III and IV; 4) Grade 8: Section V-VIII* (MEN, 2017).

It is worth mentioning that most of the teaching content in the current core curriculum, which is related to health education, has more or less direct equivalents in a 4th grade science course and a biology course for grades 5 to 8 in the forthcoming curriculum, thus the prepared analysis can be universal. In Table 3, the corresponding subparagraphs for grade 4 of science and biology for grades 5 to 8 of the upcoming curriculum were applied to the teaching content of the current grade 4 to 6 science curriculum.

Health awareness and students' social competences, knowledge and skills

The terms *knowledge, skills and social competences*, as recommended by the European Parliament and the Council of 23 April 2008, can be cited by the Dictionary of Basic Terms for the national qualification system (Sławiński, Dębowski and others 2014):

- Social competence is defined as *the ability to shape one's own development and the autonomous and responsible participation in professional and social life, including the ethical context of one's own conduct*,
- Knowledge (sometimes referred to as "information") is defined as *a set of facts, principles, theories and practice descriptions adapted in the learning process related to a learning field or an occupational activity*,

No.	subject	grade	the content of the record
science			
III. Weather, weather components, weather observation. Student:			
7.	science	IV	describes the principles of safe behaviour during the occurrence of dangerous weather conditions (storm, hurricane, snowstorm);
V. Me and my surroundings. Student:			
1	science	IV	proposes types of leisure and defines safety rules associated with them;
2			describes the pathways of pathogen infiltration into the human body, describes ways of preventing diseases;
4			interprets signs of substances harmful to health: irritating, toxic, corrosive and explosive;
5			gives the rules for behaviour and first aid in case of a bite, sting, and consumption or contact with a poisonous plant;
6			recognizes poisonous plants and animals that are venomous or pose a threat to life and health;
7			presents basic principles of tending to a damaged skin;
8			explains what an addiction is, gives examples and describes the consequences; explains why you should not take stimulants and energizers or use cell phones for too long;
9			identifies harmful substances by packaging: irritating, toxic, corrosive and explosive and explains their significance;
10			describes the principles of a healthy lifestyle (including healthy eating).
VI. Natural environment of the nearest area. Student:			
10	science	IV	recognizes common edible and poisonous mushrooms, describes the importance of fungi in the environment and in human life;
biology			
II. Diversity of life – section 2. Viruses – non-cellular forms of matter. Student:			
2	biology	V	describes the path of spread and the principles of preventing diseases caused by viruses (influenza, smallpox, rubella, mumps, measles, AIDS).
II. Diversity of life – section 3. Bacteria – unicellular organisms. Student:			
4	biology	V	describes the path of spread and the principles of preventing diseases caused by bacteria (tuberculosis, lyme disease, tetanus, salmonellosis);
5			explains the importance of bacteria in the environment and for humans.
II. Diversity of life – section 4. Protists – organisms of a diverse cell structure. Student:			
4	biology	V	presents pathways of infection and principles of preventing diseases caused by protists (toxoplasmosis, malaria).
II. Diversity of life – section 6. Mushrooms – heterotrophic organisms. Student:			
5	biology	V	shows the importance of fungi in science and for humans.
II. Diversity of Life – section 7. Diversity and unity of the animal world: (3) Flatbeds – pupil:			
d	biology	VI	presents the path of invasion of parasitic platelets and discusses ways of preventing diseases caused by selected parasites (taenia solium, taenia saginata)
e			explains the importance of flatworms in science and for humans;
II. Diversity of life – section 7. Diversity and unity of the animal world: (4) nematode – pupil:			
c	biology	VI	presents the path of invasion of parasitic nematodes (trichina worm, worms and pinworm) and discusses ways of preventing human diseases caused by these parasites
d			presents the importance of nematodes in science and for humans;
II. Diversity of life – section 7. Diversity and unity of the animal world: (6) Arthropods – pupil:			
c	biology	VI	explains the importance of arthropods (including forms of parasites and pests) in science and for humans;
III. Human body – section 2 Skin. Student:			
3	biology	VII	explains the need for medical consultation in the event of any disturbing changes in the skin;
4			gives examples of skin diseases (skin mycoses, melanoma) and the principles of its prevention;
5			determines the association between excessive exposure to UV radiation and increased risk of skin cancer development and progression.
III. Human organism – section 3 Musculoskeletal system. Student:			
4	biology	VII	explains the necessity of physical activity for the proper construction and functioning of the musculoskeletal system;
5			gives examples of musculoskeletal disorders (spinal curvature, flatulence, rickets, osteoporosis) and the principles of their prevention.

Table 2: Specific learning objectives for health education covered by the 4th grade science course and the biology course in grades 5 to 8. (2nd educational stage).

No.	subject	grade	the content of the record
III. Human organism – section 4 Digestive system and nutrition. Student:			
2	biology	VII	recognizes (in diagrams, drawings, models, etc.) the types of teeth and determines their importance in mechanical food processing; presents the causes of caries and the principles of its prevention;
3			presents food sources and explains the importance of nutrients (proteins, sugars, fats, vitamins, minerals and water) for the proper functioning of the body; plans and conducts experiments to detect the presence of selected nutrients in food products;
5			analyses the effects of some vitamin (A, D, K, C, B6, B12) and mineral (Mg, Fe, Ca) deficiencies in the body and the effects of improper vitamin and mineral supplementation;
6			presents the role of fibre in the functioning of the digestive system and explains the need for systematic consumption of fruits and vegetables;
7			explains the need for a diversified diet, that is adapted to the needs of the body (age, sex, health, physical activity, etc.), calculates the body mass index, presents and analyses the health consequences of inappropriate nutrition (obesity, overweight, anorexia, bulimia, diabetes);
8			gives examples of gastrointestinal diseases (hepatitis A, hepatitis B, hepatitis C, gastric and duodenal ulcers, food poisoning, colorectal cancer) and the principles of their prevention.
III. Human organism – section 5 Cardiovascular system. Student:			
5	biology	VII	plans and observes the effects of exercise on the changes in heart rate and blood pressure;
6			analyses the impact of physical activity and the correct diet on the functioning of the cardiovascular system;
7			gives examples of blood diseases (anaemia, leukaemia), circulatory system diseases (atherosclerosis, hypertension, myocardial infarction) and principles of their prevention;
8			explains the need for periodic blood tests and pulse and blood pressure measurements.
III. Human organism – section 6 Immune system. Student:			
3	biology	VII	compares the essence of vaccine and serum operation; gives indications for their use and explains the need for compulsory vaccination;
4			identifies the situation in which a serological conflict occurs and foresees its effects;
5			presents the importance of transplants and organ transplant consent;
6			identifies allergy as immune system hypersensitivity to the specific factor;
7			identifies AIDS as an immune mechanism disorder.

No.	subject	grade	the content of the record
III. Human organism – section 7 Respiratory system. Student:			
5	biology	VII	analyses the effects of smoking (passive and active) and dust pollution on the condition and functioning of the respiratory system;
6			gives examples of respiratory diseases (quinsy, tuberculosis, lung cancer) and the principles of their prevention.
III. Human organism – section 8 Urinary system and excretion. Student:			
3	biology	VII	gives examples of urinary tract diseases (urinary tract infections, kidney stones) and the principles of their prevention;
4			explains the need for periodic urine testing
III. Human organism – section 9 The nervous system. Student:			
4	biology	VII	presents ways to deal with stress;
5			explains the importance of sleep in the proper functioning of the nervous system;
6			presents the negative impacts on the functioning of the nervous system created by some psychoactive substances: alcohol, drugs, doping, designer drugs, nicotine (including e-cigarettes), or the abuse of caffeine and certain medications.
III. Human organism – section 10 Sensory organs. Student:			
2	biology	VII	presents the causes and the ways of correcting sight defects (near-sightedness, farsightedness, astigmatism);
4			describes the impact of noise on human health;
III. Human organism – section 11 Endocrine system. Student:			
3	biology	VII	explains why you should not take hormonal medications without consulting your physician.
III. Human organism – section 12 Reproduction and development. Student:			
6	biology	VII	presents the principles of preventing sexually transmitted diseases;
7			explains the need for screening as a means of early breast cancer, cervical cancer and prostate cancer diagnosis.
IV. Homeostasis. Student:			
2	biology	VII	represents health as a state of balance of the internal environment of the body and disease as a disorder of homeostasis;
3			analyses the information included with medicines and explains why you shouldn't take over-the-counter medicines and supplements without a specific reason;
4			explains that antibiotics and other medicines should be used according to doctor's recommendations (dose, time of administration and duration of treatment)

No.	subject	grade	the content of the record
V. Genetics. Student:			
5	biology	VIII	presents tumours to be a result of uncontrolled cell division and presents factors conducive to their development (e.g. improper diet, some stimulants, poor lifestyle, UV radiation, environmental pollution);
8			gives examples of sex-linked diseases (haemophilia, colour-blindness) and describes their inheritance;
10			describes what is a mutation and lists the possible causes of its occurrence (spontaneous and mutagenic mutations) and provides examples of mutagenic factors (UV radiation, X-rays, tobacco smoke components, mould fungi toxins, HPV virus);
11			gives examples of human genetic disorders associated with mutations (cystic fibrosis, phenylketonuria, Down syndrome).

Requirement No. (CC 2009)	fragment of the content of the record	Equivalent record – CC 2017			
		science	grade	biology	grade
1. Me and my surroundings. Student:					
1	provides the positive and negative influences on his or her mood ...	-	-	III.9.4	VII
2	explains the importance of rest (including sleep) ...	-	-	III.9.4, III.9.5	VII
3	presents the principles of proper learning and applies them in his or her life;	-	-	III.9.4	VII
4	describes a properly designed learning place for a pupil…	-	-	III.9.4	VII
5	explains the need for day and week planning…	-	-	III.9.4	VII
6	(...) applies safety rules during observation ...	V.6	IV		
9	recognizes and names some plants (...) containing poisonous or harmful substances ...	-	-	III.2.5 III.7.5 V.5	VII VII VIII
5. Man and the environment. Student:					
5	gives examples (...) of the environmental impact on human health;	-	-	III.2.5 III.7.5 V.5	VII VII VIII
9. Health and health care. Student:					
1	gives examples of the negative impact of selected species of animals, plants, fungi, bacteria and viruses on human health, lists ways to prevent the diseases that are transmitted and caused by them;	V.2 VI.10	IV IV	II.2.2 II.3.4 II.3.5 II.7.3.c II.7.3.d II.7.6.c III.6.3 III.6.6 V.10	VI VI VI VI VI VI VII VII VIII
2	lists rules for dealing with food products ...	V.10	IV	-	-
3	lists the principles of proper nutrition and applies them;	V.10	IV	III.4.5 III.4.6 III.4.7	VII VII VII
4	gives and applies the rules of caring for their own body ...	V.10	IV	III.2.4	VII
5	explains the basic principles of the sight and hearing protection;	V.10	IV	III.10.2 III.10.4	VII VII
6	explains the importance of movement ...	V.10	IV	III.3.4 III.3.5	VII VII
7	gives examples of proper leisure time ...	V.1	IV	-	-
8	describes the rules of first aid ...	V.5	IV	-	-
9	gives examples of behaviours and situations that may endanger human health and life ...	-	-	-	-
10	explains the meaning of symbols placed on e.g. packaging ...	V.4	IV	-	-
11	lists the basic principles of safe behaviour at home ...	-	-	-	-
12	explains the negative impact of alcohol, nicotine ...	V.8	IV	III.9.6 V.10	VII VIII
13	lists the principles of a healthy lifestyle ...	V.10	IV	III.3.4 III.4.7 III.5.6	VII VII VII
10. Electrical and magnetic phenomena in science. Student:					
4	... describes and applies the principles of safe handling of electrical equipment;	-	-	-	-

Table 3. Current science curriculum (grades 4-6) and the upcoming curriculum for science (4) and biology (5-8) – comparison. Indications: CC – core curriculum, "-" – no corresponding entry in the upcoming program for biology and science courses in elementary school.

- And skills are defined as *the ability to perform tasks and solve problems specific to a learning field or an occupational activity.*

The aforementioned study assumes that health behaviours are a derivative of health consciousness, although this is not always the case. Consciousness corresponds to responsibility for one's behaviour (Puchalski, 1994, Słońska 1994). Taking this fact into consideration it was stated that, the school (and also didactic textbooks and other aids) should influence pupils' emotions in the process of shaping their health knowledge. Otherwise, their behaviour will most likely not reflect either their knowledge or skills.

Ratajczak explains that health awareness is a cognitive structure that directs and organizes people's health-related activities. According to Woynarowska, health consciousness depends on three components (Woynarowska, 2017): (1) *structures that perceive signals of health hazards,* (2) *health and disease knowledge, derived from various sources, [*in particular *obtained ...] as an effect of one's own experiences with the consequences of health choices,* and (3) *health's place in the one's value hierarchy.*

According to the premise of this study, the student's health awareness should be expressed by the student's analysis of problematic situations that are described in the subject textbook. **Awareness should also be a reflection the student's personal experience** (according to the fragment of Woynarowska's definition quoted above). Through such deliberations, a student can gain both the knowledge and the ability to make choices conducive to his or her health improvement and the value of such choices.

Purpose and objectives of the study, research questions

The main objectives of the study were:

- examining the content of science textbooks for grades 4–6 (in accordance with the current curriculum), with particular emphasis on the development of practical skills for implementing health knowledge. The above refers to the 3rd[4] and 5th[5] objective of educational curriculum in science for the second stage of education.
- assess whether the layout and content of the textbooks refer to aspects of the students' health consciousness – whether they relate to their emotions and prior experience.

Basic research questions corresponding to the objectives:

How much does the content of the reviewed textbooks correspond with the current curriculum?

Has the content of the textbook been extended from the objectives detailed in the current curriculum? If so, which contents were extended?

What health skills help shape the science textbooks?

Do the ways of presenting content related to health education affect the development of a students' awareness or, above all, the broadening of their knowledge in this field?

4 **3rd Objective of education:** Practical use of natural science knowledge. *The student is aware of the surrounding nature and culture; recognizes health and life-threatening situations and undertakes actions to increase their own and other's safety, consciously works to protect one's health.*

5 **5th Objective of education**: Observations, measurements and experiences. *The student uses various sources of information (own observation, research, experiments, texts, maps, tables, photographs, films), performs measurements and uses instructions (verbal, written and graphic); documents and presents the results of observations and experiences; uses information and communication technologies.*

Materials and methods

The study was constructed analogously to the study described in the monograph *Handbook of Life Sciences in the XXI Century*, edited by Piotr Bieńka, in the chapter: *The scope of health education in textbooks for the Nature courses* (Chrzanowski, Gawrońska, Aszklar, Piszczek, 2016). The methodology used is briefly described below[6].

The initial phase of the study involved the preparation of a research tool (a large Excel spreadsheet) in the form of an external category grid that was searched for during the textbook analysis. The grid was created after analysing the curriculum of general education for the science course in the second stage of education and then distinguishing the content concerning health education. The list of entries is shown in Table 1.

There are no records of how (by what means) the contents of the curriculum should be implemented into the textbooks. To distinguish the main ways of presenting information in textbooks, a pilot analysis of randomly selected two textbooks was conducted. In addition, the tools used in another textbook evaluation for chemistry in middle schools were analysed. (Musialik, Chrzanowski, Buczek, Arèvalo-Garcia and Ostrowska, 2013) Based on the above analysis, two categories of elements were identified to be assessed:

- form of presentation (graphic or text) and
- the function that the tested item has to fulfil (Figure 1).

The conducted analysis of textbooks was both quantitative and qualitative, as shown in Figure 2 (Pingel, 2009). Quantitative analysis can be used to quantify how much emphasis is placed in these textbooks on

6 Text based on a chapter in a monograph: Handbook of Life Sciences in the XXI Century: *The scope of health education in textbooks for the Nature courses* (Chrzanowski, Gawrońska, Aszklar, Piszczek, 2016).

a particular topic. The quantitative measurement has also shown how often a given topic was discussed in the textbooks and the physical amount of space that was used in to describe the problem. The qualitative analysis was performed in order to supplement the analysis with a slightly more subjective interpretation and evaluation of the analysed elements. In this case, the study assessed what the graphics (text, etc.) say, how it's done, what information is conveyed, and what emotion it represents.

All analysed textbooks can be found on *the list of school-approved textbooks for general education, based in the new core curriculum for pre-school education and general education for specific types of schools* (List of school-approved textbooks, MEN, 2016). The list of analysed textbooks is presented in Table 4. The textbooks from the *Przyroda. Odkrywamy na nowo* series (Wydawnictwo Pedagogiczne, OPERON Sp. z o.o.) are not available on the market. Therefore, the results of the study do not take their impact on teaching-learning categories included in the research questions. The study did not include didactic aids for the given textbooks.

It should also be noted here that the analysis performed was not intended to create rankings or to evaluate textbooks. It was only intended to interpret what elements of textbooks can influence the development of pupils' competences.

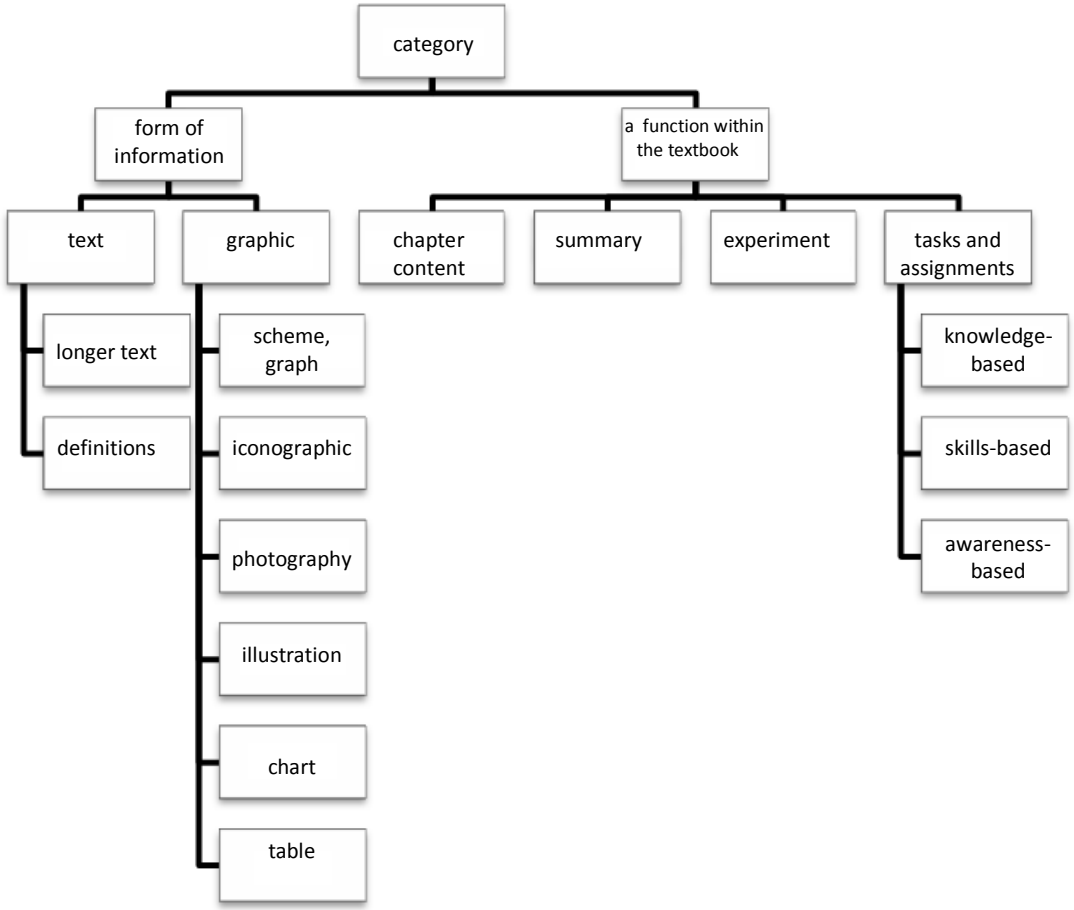

Figure 1: Categories of elements analysed in the studied textbooks

Based on (Chrzanowski, Gawrońska, Aszklar, Piszczek, 2016).

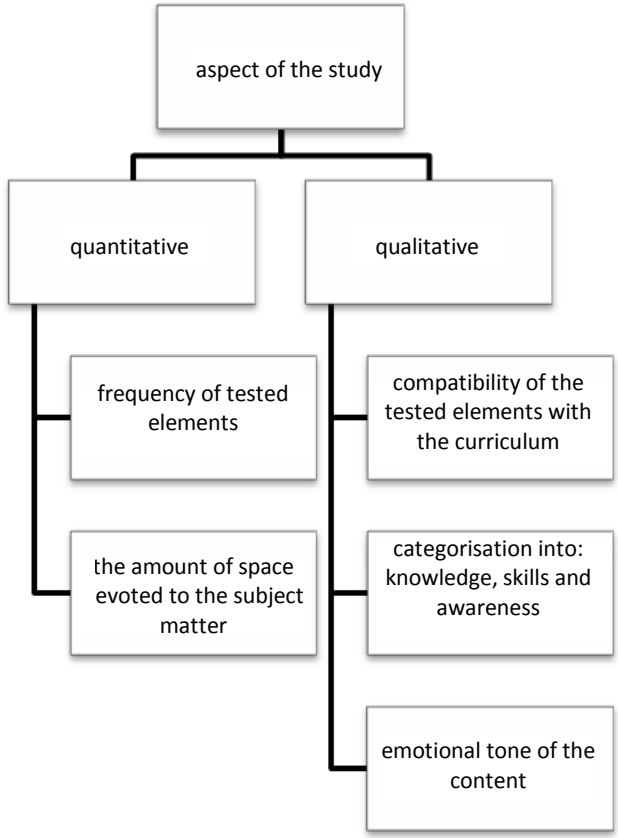

Figure 2: Graphic representation of aspects used in the textbooks assessment

Based on (Chrzanowski, Gawrońska, Aszklar, Piszczek, 2016).

series title	No.	abbreviation	textbook's title	textbook's author	editor
Przyroda-poznać i zrozumieć	1.1	Wiking 4	Przyroda – podręcznik dla klasy czwartej szkoły podstawowej	Brygida Baranowska, Elżbieta Szedzianis, Robert Wers, Romana Woźnik	Wiking
	1.2	Wiking 5	Przyroda. Podręcznik dla klasy piątej szkoły podstawowej	Brygida Baranowska, Elżbieta Szedzianis, Robert Wers, Romana Woźnik	
	1.3	Wiking 6	Przyroda – podręcznik dla klasy szóstej szkoły podstawowej	Brygida Baranowska, Elżbieta Szedzianis, Robert Wers, Romana Woźnik	
Tajemnice przyrody	2.1	NE 4	Tajemnice przyrody. Podręcznik dla klasy 4	Maria Marko-Worłowska, Feliks Szlajfer, Joanna Stawarz	Nowa Era 1
	2.2	NE 5	Tajemnice przyrody 5. Podręcznik dla klasy 5 szkoły podstawowej	Janina Ślosarczyk, Ryszard Kozik, Feliks Szlajfer	
	2.3	NE 6	Tajemnice przyrody. Podręcznik dla klasy 6	Joanna Stawarz, Feliks Szlajfer, Hanna Kowalczyk	
Przyroda. Ciekawi świata	3.1	OP 4	Przyroda 4. Podręcznik dla szkoły podstawowej	Małgorzata Augustowska, Małgorzata Gajewska	OPERON
	3.2	OP 5	Przyroda 5. Podręcznik dla szkoły podstawowej	Małgorzata Augustowska, Elżbieta Bytniewska, Małgorzata Gajewska, Marzena Karwowska	
	3.3	OP 6	Przyroda 6. Podręcznik dla szkoły podstawowej	Małgorzata Augustowska, Elżbieta Bytniewska, Małgorzata Gajewska, Marzena Karwowska	
Przyroda z klasą	4.1	Klett 4	Przyroda z klasą. Podręcznik dla klasy 4 szkoły podstawowej	Joanna Buniowska, Ewa Frąckowiak, Ewa Gęca, Przemysław Jeruszka	LektorKlett
	4.2	Klett 5	Przyroda z klasą. Podręcznik do klasy 5	Joanna Buniowska, Ewa Frąckowiak, Ewa Gęca	
	4.3	Klett 6	Przyroda z klasą. Podręcznik do klasy 6	Joanna Buniowska, Ewa Frąckowiak, Ewa Gęca	
Przyrodo, witaj!	5.1	WSiP 4	Przyrodo, witaj! Podręcznik dla klasy 4 szkoły podstawowej	Ewa Gromek, Ewa Kłos, Wawrzyniec Kofta, Ewa Laskowska, Andrzej Melson	WSiP 1
	5.2	WSiP 5	Przyrodo, witaj! Podręcznik dla klasy 5 szkoły podstawowej	Ewa Gromek, Ewa Kłos, Wawrzyniec Kofta, Ewa Laskowska, Andrzej Melson	
	5.3	WSiP 6	Przyrodo, witaj! Podręcznik dla klasy 6 szkoły podstawowej	Ewa Gromek, Ewa Kłos, Wawrzyniec Kofta, Ewa Laskowska, Andrzej Melson	
Na tropach przyrody	6.1	Era 4	Na tropach przyrody. Podręcznik dla klasy 4	Marcin Braun, Wojciech Grajkowski, Marek Więckowski	Nowa Era 2
	6.2	Era 5	Na tropach przyrody. Podręcznik dla klasy 5	Marcin Braun, Wojciech Grajkowski, Marek Więckowski	
	6.3	Era 6	Na tropach przyrody. Podręcznik dla klasy 6	Marcin Braun, Wojciech Grajkowski, Marek Więckowski	
Przyroda w szkole podstawowej	7.1	Żak 4	Przyroda 4. Podręcznik dla uczniów klasy 4 szkoły podstawowej	Barbara Klimuszko, Janina Sokołowska, Maria M. Wilczyńska-Wołoszyn	Żak
	7.2	Żak 5	Przyroda 5. Podręcznik dla uczniów klasy 5 szkoły podstawowej	Berenika Targos-Panak, Maria M. Wilczyńska-Wołoszyn	
	7.3	Żak 6	Przyroda 6. Podręcznik dla uczniów klasy 6 szkoły podstawowej	Leszek Bober, Berenika Targos-Panak, Maria M. Wilczyńska-Wołoszyn	
ABC przyrody	8.1	ABC 4	Przyroda. Podręcznik dla 4 klasy szkoły podstawowej	Barbara Gulewicz, Beata Brzozowska-Michałek, Anna Lauda-Michalska, Joanna Piętka-Baumgart, Beata Ziółkowska	ABC
	8.2	ABC 5	Przyroda. Podręcznik dla klasy 5 szkoły podstawowej	Barbara Gulewicz, Anna Lauda-Michalska, Joanna Piętka-Baumgart, Beata Ziółkowska	
	8.3	ABC 6	Przyroda. Podręcznik dla 6 klasy szkoły podstawowej	Barbara Gulewicz, Anna Lauda-Michalska, Joanna Piętka-Baumgart, Beata Ziółkowska	
Przyroda z pomysłem	9.1	WSiP 4 PzP	Przyroda z pomysłem. Część 1 i 2. Podręcznik dla klasy 4 szkoły podstawowej	Urszula Depczyk, Bożena Sienkiewicz, Halina Binkiewicz	WSiP 2
	9.2	WSiP 5 PzP	Przyroda z pomysłem. Część 1 i 2. Podręcznik dla klasy 5 szkoły podstawowej	Urszula Depczyk, Bożena Sienkiewicz, Halina Binkiewicz	
	9.3	WSiP 6 PzP	Przyroda z pomysłem. Część 1 i 2. Podręcznik dla klasy 6 szkoły podstawowej.	Urszula Depczyk, Bożena Sienkiewicz, Halina Binkiewicz	

Table 4: List of analyzed textbooks

Abbreviation description: Wiking – Wiking "Wydawnictwo Edukacyjne" Wiking "Sp. j., Nowa Era – Nowa Era Spółka z o.o., OPERON – Wydawnictwo Pedagogiczne OPERON Sp. z o.o., WSiP – Wydawnictwa Szkolne i Pedagogiczne Sp. z oo, Żak – Wydawnictwo Edukacyjne "Żak" sp. z o.o. sp. k., ABC – Wydawnictwo ABC spółka z o.o See Appendix 1 for a description of the abbreviations used in the publication to indicate specific textbooks.

Results and discussion

In view of the a wide range of the analysed materials, a review it conducted, that included a possible influence of textbooks on shaping children's and young people's health awareness using selected specific learning objectives included in the core curriculum (for the science course in the second educational stage):

1. Me and my surroundings,
5. Man and environment and
10. Electrical and magnetic phenomena in science[7].

Individual sections are described separately as divided by subsequent textbooks for grades 4-6 and consecutive (semantically consistent) fragments of individual content records.

Section 1. Me and my surroundings

1.1. Lists positive and negative influences on his or her well-being at school and at home (...)[8]

In the Era 4 textbook, the issue of well-being at school has been presented in a form of a short story. The authors highlighted the importance of pupils' correct relationship with their peers and teachers and positive learning results on their well-being in school. The influence of health and interests on their well-being at home or at school was not covered by the book. In addition, the problem of pupil's well-being at home has not been addressed in the textbook at all. In the questions under a chapter, students receive examples of problem solving situations that pose as a test of their ability to maintain their well-being at school. The authors of WSiP 4 PzP textbook listed eight factors that cause the student's malaise at school. The chapter in which the subject is discussed is entitled "Well-being at school and at home", however, no reference to the determinants of the well-being of the student at home not any definitions of the term *well-being* was found. Domestic trouble was however mentioned among the factors that cause student's bad mood in school. The authors did not bring this issue closer in the text. The questions under this chapter are designed to test the student's ability to master the content presented during the discussion. Unfortunately, students do not find questions that involve their emotions or that improve their ability to speak about their own feelings within this textbook. The authors of the ABC 4 textbook listed the following factors that affect the well-being of a student at school: physical activity, leisure, healthy eating and sleep. The importance of relationships was only mentioned by the authors within one sentence. Most of the questions listed below are related to the student's knowledge. The questions completely ignore the importance of emotions and relationships with other people (peers, teachers, parents and siblings) for the well-being of children at school and at home. No questions that shape the student's health consciousness were found either. The authors of Op 4 textbook describe seven situations that affect student's well-being of at school. They mention the principles of social coexistence that allow us to shape relationships with other people. With the help of the photos, they teach the proper recognition of emotions that other people can feel, thereby contributing to the development of empathy in the pupils. The authors of Żak 4 textbook list several factors that influence people's well-being. The text on this subject is very concise, but the questions under the chapter encourage the students to reflect on their own feelings about the school and its environment. The authors of WSiP 4 textbook discuss several important factors that shape the well-being of a student at school. They also provide some good advice on how to behave in order to be popular among peers. They also raise the issue of shyness. The questions under this chapter are designed to test the students' knowledge, skills and develop their health awareness. The authors did not mention the issue of students' well-being at home.

(...) suggests ways of eliminating negative factors[9]

The authors of the Era 4 textbook have presented a short story suggesting several ways to eliminate negative factors to improve children's well-being at school. Based on the story, students can come to the conclusion that the ability to ask their teachers or colleagues for help can help overcome learning difficulties. In the story, important factors that affect the students' well-being are missing: health, interesting leisure time, positive attitudes towards oneself and the environment. The WSiP 4 PzP textbook lists a number of ways to effectively improve students' well-being at school and at home. It is important for the students to know where they can seek help in difficult situations that they cannot handle by themselves. The authors have mentioned a nationwide telephone number, which the student can use in extremely difficult situations. There is a very valuable message for students implying that their well-being depends to a great extent on their behaviour. The illustrated guide includes a number of practical tips on how to improve one's well-being which can be used by a student in their everyday lives. The textbook doesn't include questions directed at a student regarding their own effective ways to improve their mood. Unfortunately, the only question related to the subject asks to re-

7 Section 9 *Health and health care* analysis can be found in publications by Chrzanowski's and co-authors (Chrzanowski, Gawrońska, Aszklar, Piszczek, 2016).

8 The following textbooks do not cover these topics: Klett 4, Wiking 4, Żak 5, ABC 5, Klett 5, Op 5, WSiP 5, Era 5, WSiP 5 I PzP, WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP, WSiP 6, NE 6.

9 The following textbooks do not cover these topics: Klett 4, Wiking 4, Żak 5, ABC 5, Klett 5, Op 5, WSiP 5, Era 5, WSiP 5 I PzP , WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP, WSiP 6, NE 6.

produce the information contained in the text. The ABC 4 textbook focuses on the physiological factors that influence the student's well-being at home and school. Therefore, the listed means to eliminate negative factors are related to physical activity, rest, healthy eating, and sufficient sleep. The authors did not mention any interesting forms of spending free time, developing interests, building positive relationships with their peers at school or the rules of proper communication with teachers and parents. The importance of emotion and mental health for the well-being of children has therefore been omitted. In the Op 4 textbook, the students find suggestions for behaviours and activities that can improve the atmosphere in their family home. They also learn what situations should be avoided to make sure their relationships with peers are as good as possible. Among the assignments under the chapter, the authors placed a task in which they encouraged students to consider ways to help a fellow student who is confused and experiences learning difficulties. In addition, the next task asks to present their own ideas to improve the well-being of their families. Both tasks aim to develop students' empathy towards other people. The authors of the Żak 4 textbook appreciate the importance of science contact in everyday well-being. In the exercise no. 3 on page 17, students have an opportunity to propose their own ways of eliminating adversities that affect their well-being at school and at home. The authors of the WSiP 4 textbook provide examples of behaviours that can improve the schoolchildren's well-being. They provide ways to gain sympathy from their peers, but also focus on the problems of shy and disabled people. The questions under the chapter test students' knowledge and skills, but also develop their health awareness.

1.2. explains the importance of rest (including sleep), nutrition and physical activity in the proper functioning of the body[10]

The WSiP 4 PzP textbook describes the importance of proper nutrition, physical activity, rest, including sleep for human health. Using the illustration, the authors presented examples of the correct and incorrect school lunches. The textbook does not mention any information concerning the fact that an inadequate diet containing large amounts of sweets, salty and fatty snacks and fast foods, often leads to childhood obesity, which can cause serious adult illnesses. Discussing the importance of physical activity for the body, the authors also did not expand on the problem of obesity, which is becoming more and more common in the society. Most of the questions under this chapter are designed to test the student's knowledge gained from the text. One of them relates to the influence of students' physical activity on their health and contributes to the development of health consciousness. The authors of the ABC 4 textbook focused primarily on discussing the principles of healthy eating and their importance to young person's health and well-being. The book contains a food pyramid and a sample menu for the primary school pupil. In addition, so-called organic products were mentioned to play a role in proper nutrition. The exercise listed under a chapter instructing the student to plan a healthy meal, e.g. a school lunch, is very important for the students' ability to develop their skills and health-consciousness. A separate chapter was devoted to the topic of healthy eating, while the importance of sleep, various forms of active and passive rest was discussed in a rather lapidary way. The authors of the Op 4 textbook described the importance of sleep, rest and physical activity for the proper functioning of the body in the chapter titled: "The body needs to be taken care of". Using the graph, they presented a student's daily activity cycle. In this chapter, a student can find tasks that allow him or her to develop the ability to analyse data contained in charts and tables and to draw conclusions. In addition, the instruction to develop a leaflet encouraging physical activity for students and their parents can help shape health awareness. The importance of proper nutrition for human health is described in a separate chapter entitled "Healthy eating prevents illnesses." The authors offered examples of products that a student can eat for breakfast and lunch. While planning their diet students can use the pyramid provided in the textbook. They also have the opportunity to review the rules of healthy eating, as well as practice their calorie intake with sweet snacks. In the Żak 4 textbook, students find information related to the meaning of rest and physical exercises for everyday strength regeneration. The authors have included a question addressed to the students regarding their behaviour, which would prevent them from being tired. Two illustrations also remind students of the need to rest. Unfortunately, there are no questions about the topic. Moreover, the authors skipped important topics of healthy eating, which are necessary for proper functioning of the body.

In the ABC 5 textbook the issue is presented in two separate sections: in section 3. – "Human organism" and section 4. – "Health and heath care". They focus mostly on the importance of proper diet in the proper functioning of the body. This topic is covered in both of the above-mentioned sections of the textbook. They point to the need for a balanced diet in everyday life. The term "balanced diet" has been introduced and defined in Chapter 3. In the next health section, pupils are given a task to observe their diet to determine if it's balanced. The authors also suggested to perform a comparison exercise of the composition of three carrot juices with different expiration dates to determine

10 The following textbooks do not cover these topics: Klett 4, WSiP 4, Op 6, Wiking 6, Klett 6, ABC 6, NE 6.

their suitability for consumption. The element of observation in the teaching process used by the authors of the ABC 5 textbook, can contribute to the students' health awareness development while discussing issues related to the importance of nutrition for the proper functioning of the human body. Unfortunately, the importance of physical activity and rest in human health is much less exposed in this textbook. Any tasks aimed at health awareness improvement in this topic are also missing. In addition, the authors completely ignored the role of sleep in the proper functioning of the body. The Klett 5 textbook describes in detail the role of individual nutrients in the human body and the importance of physical activity and sufficient sleep for the health and well-being of all systems and organs. The authors place too little weight on shaping and developing the students' health awareness. Therefore it lacks instructions and questions that directly address their dietary preferences, as well as their most common physical activities. In the Op 5 textbook, the authors describe the importance of proper nutrition, physical activity and rest for human health in quite great detail. These contents are discussed in two sections: in section 3. "Human organism" and in section 4. "Health and health care". The authors introduced an experiment to the educational process recommending the students to examine their pulse before and after exercise. The WSiP 5 textbook provides information on the role of individual nutrients in the human body and the importance of physical activity for overall fitness. It was also stressed that adequate sleep is needed for proper functioning of the body. This book provides tips on how to ensure a healthy sleep. The tasks addressed to pupils do not, however, develop their health consciousness. In the Era 5 textbook, the authors describe the importance of eating for the proper functioning of the human body, but completely overlook the role of rest (including sleep). They recommended sports and active games for the proper functioning of muscles and bones. The topic of nutrition is described in two chapters: "Why do we eat and drink?" and "How to eat healthy?". In order to make students aware of the importance of proper nutrition for human health, the authors used two graphics. The first one on page 136 illustrates two basic functions of food, and the other, on page 139 shows different types of foods and their function in the body and how much they should be consumed. The second one of these serves as a food pyramid and can be used by students to plan their own diet. The WSiP 5 II PzP textbook explains the role of particular nutrients in the functioning of the organism and, what's important, the negative effects of improper nutrition on the health and well-being of humans. It also explains why physical activity is a prerequisite for maintaining good health. It was emphasized that regular sport activities and exercise affect the proper functioning of the blood and respiratory system. In order to prove the importance of physical activity for the functioning of the circulatory system, an experiment entitled "Does physical activity affect heart rate?" was introduced. The role of sleep and rest in maintaining health was also mentioned. The Wiking 5 textbook explains the importance of physical activity and proper nutrition for the human body. Least focus was allocated to describe the meaning of sleep and rest for human health. It was only mentioned that well-planned rest and adequate sleep strengthens the body's immune system and helps to prevent infectious diseases. In order to develop the student's health consciousness, the authors placed questions about the benefits that students derive from their sports discipline. There was also an important task to convince your peers to sign up for the School Sports Club.

The authors of the Żak 6 textbook, used a graph to illustrate the energy needs of humans in terms of age while discussing the importance of proper nutrition for the proper functioning of the body. This gives the 6th grade student an opportunity to gain valuable skills in analysing charts. Unfortunately, the questions under the chapter do not address the problem. The importance of physical activity and rest for the human body has been extensively discussed in the text. Also, in the questions under this chapter, the authors referred to this issue by examining the students' knowledge as well as their ability to formulate conclusions. In part II of the WSiP 6 PzP textbook, in section: "Knowledge recap before middle school", the authors mentioned the role of nutrients for the proper functioning of the human body and introduced a food pyramid. Issues related to the importance of rest and physical activity were not mentioned by the authors. There are no questions to assess the students' knowledge and skills. The authors of the section titled: "Knowledge recap – how to be healthy?" in the WSiP 6 textbook reminded the students of the four basic principles of healthy eating and proper ways of spending free time. They missed the importance of sleep for the proper functioning of the body. The questions under the chapter refer only to the ways of spending free time and the importance of physical active for health.

1.3. Lists the principles of correct learning (...)[11]

Students, who use the Wiking 4 textbook learn the correct learning principles. They learn about the necessity of solidifying knowledge by regular repetition. The authors also emphasize that the effectiveness of learning is also influenced by systematic, daily homework done at the same time every day, starting with the most difficult task and taking short breaks in learning. The authors concisely warn against doing homework too late in the

11 The following textbooks do not cover these topics: Żak 5, ABC 5, Klett 5, Op 5, WSiP 5, Era 5, WSiP 5 I PzP , WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP , WSiP 6, NE 6.

evening. However, they do not explain why it is not advisable to do homework too late. This textbook contains an illustration that encourages the students to clarify what factors distract them from doing homework. The authors of the Era 4 textbook have listed and widely described the five principles of effective learning. The text has been completed with a photo encouraging students to visit interesting places such as the zoo and with drawings that can inspire pupils to develop their own effective learning methods. At the end of this chapter, the authors provided a short poem, suggesting that the conditions and the place are very important in learning. At the end of the chapter there is a question about the student's knowledge of the principles of effective learning. The authors of the WSiP 4 PzP textbook have listed six principles of good learning. They also drew attention to several factors related to conditions and student attitudes that may help or hinder the learning process. The authors have included a sample mind map about science, but they have not explained in the text that creating a variety of schemes is a good way to understand and memorize the curriculum content. The question related to the learning principles presented under the chapter is reproductive. The authors of the ABC 4 textbook have listed three principles of correct learning. They pointed out that learning begins in the classroom, and included some important advice on how to make the most out of the lesson time so that you could effectively master the issues discussed. They also stressed the importance of frequent knowledge repetition and the use of appropriate learning techniques that differ between visualizers, audiles and kinaesthetic. The questions at the end of this chapter check students' knowledge and skills in the subject matter discussed. The authors of the Op 4 textbook list and briefly describe three principles of proper learning. They drew attention to systematic learning, concentration and well-utilized lesson time, as well as tests preparation. Students who use the textbook can also offer fellow students ways to improve their learning. In addition, the last task listed under the chapter commanding students to talk about school success, that gave them the most joy, allows them to share their emotions with others. In the Żak 4 textbook, the principles of correct learning have been described by the authors in a uniform text. There are no bullet points to help students learn. Interwoven questions related to the students' learning conditions encourage them to reflect and draw conclusions. The authors of the Klett 4 textbook briefly discuss the principles of proper learning. They highlighted the importance of rest, proper nutrition, learning breaks, and effective planning for effective learning. They skipped the importance of effective time utilisation during school lessons, attention, and frequent repetition of the content. Under the chapter we find one question related to these issues, which is reproductive. The authors of the WSiP 4 textbook have listed seven principles of good learning. They emphasized the importance of systematism for achieving positive results in science. You will also find the characteristics of a good student, as well as the possible causes for learning difficulties. The questions under the chapter tests the students' knowledge related to the problem and their ability to analyse and draw conclusions.

1.3. Applies the rules of proper learning in life[12]

The authors of the Wiking 4 textbook while discussing the principles of correct learning, have put questions addressed to the student regarding his or her learning principles, and the factors that help or distract them during studying. The authors of the Era 4 textbook have proposed two simple practical exercises that consist in comparing the effectiveness of word memorization. In the first exercise, students read the words given in the textbook, then write down those they memorized. In the second one, they read words that are associated with objects in their surroundings, and then also write the ones they remembered. In the final stage, the student compares the number of words recorded in both exercises and draws conclusions. A student who uses the textbook can also use a diagram to present the contents of the frame on page 160 in the exercise at the end of the chapter. Apart from the aforementioned practical exercises and tasks to check the student's ability to visualize the content, a question regarding the methods students use in their daily life, preparing for their tests is missing. The WSiP 4 PzP textbook does not offer any practical exercises to teach students how to apply the principles of correct learning. On the other hand, while discussing the issues, authors devoted a great deal of attention to the student's attitude, including motivations and concentration abilities, which could therefore be an important element of the training, demonstrating ways of eliminating factors that have a negative impact. In the ABC 4 textbook, the authors have not proposed any practical exercises that would test and improve the students' proper learning skills. The question no. 7 on page 22 should unambiguously address the most effective learning methods used by the student. The authors of the Op 4 textbook present a table with questions that prompt students to think about diligently pursuing school duties. Moreover, they stress the importance of motivation in task performance success. The question at the end of the chapter prompts the students to reflect on the factors that help or interfere with the school work. The authors of the Żak 4 textbook recommend that students evaluate their learning style and conditions. The Klett 4 textbook does not reference to the learning principles that students use. Students, who use the WSiP 4

12 The following textbooks do not cover these topics: Żak 5, ABC 5, Klett 5, Op 5, WSiP 5, Era 5, WSiP 5 I PzP , WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP, WSiP 6, NE.

textbook cannot evaluate their learning effectiveness. The authors did not propose any tasks that would allow them to analyse their current learning methods nor did they propose any possible improvement methods.

1.4. Describes a properly designed learning place for a primary school pupil[13]

The authors of the Wiking 4 textbook describe how to organize a learning place at home. They pay attention to the correct illumination of the place, maintaining order on the desk and frequent airing of the room. The authors also emphasize the importance of proper selection of furniture for doing homework. They recommend a simple practical exercise that is designed to make students aware of the need to choose a chair and table of the right height to maintain the correct body posture during the lesson. Under this chapter, the authors provide a task to check the student's knowledge on the subject. In the Era 4 textbook there is a picture with items described, showing the correct place to learn. It draws attention to a number of important issues such as fresh air supply, proper lighting, a chair and a table of appropriate height, order on the table and access to the computer. At the end of this chapter there is a question that addresses student's knowledge of the subject. Unfortunately, the authors did not encourage pupils to describe and evaluate their own learning places. The WSiP 4 PzP textbook describes five conditions that should be met by a properly designed learning place. In the diagram, an essential condition of fresh air access to the room in which the student is learning is omitted. The questions under this chapter refer to the contents of the textbook on the properly prepared learning place. However, there is no reference to the students' situations and to the evaluation of their own place of study. In the ABC 4 textbook, the authors emphasized the importance of accepting the right position while learning. They pointed out the effects of taking wrong positions for spinal defects in students who have improperly designed study places and neglect their motor activity. The authors have provided a picture that accurately illustrates the properly arranged place of work for the student. The questions under the chapter relate to the students' knowledge contained in the text but do not develop their planning skills and health awareness. The authors of the Op 4 textbook have described how to properly organize a learning space so that the conditions and atmosphere support concentration. The picture in the book does not show all of the items that you need to include in your place of work. Health awareness and critical assessment skills are developed by the students through an assignment of their own learning place. The authors of the Żak 4 textbook included two pictures on which they presented bad and good learning conditions. The student is to evaluate his or her working place and condition using photos. The authors of Klett 4 textbook have described how a properly designed learning place should look. They did not include any photos of the student's room, which would show what a room or a learning place should be. The picture shows only the correct attitude of the student while learning. A small illustration included in the textbook only highlights the importance of proper lighting in the workplace. The question underneath the text urges the student to evaluate his or her own learning place. The authors of the WSiP 4 textbook used an illustration with the described elements to present the correct and incorrect posture of the body and a correctly and incorrectly arranged learning place. They also mentioned factors that affect learning: proper room temperature, lighting and noise. Unfortunately, there was a shortage of tasks for the students, which would allow them to evaluate their own study places.

Explains to the need to plan day and week activities (...)[14]

The authors of the Wiking 4 textbook explain the need to schedule day and week activities in a few sentences. There is, however, no clear message that planning all day-to-day activities dictates the proper management of time, so that it can also be used for the development of one's own interests or for passive and active rest. One question concerning students' knowledge related to the need for daytime scheduling is included in the chapter. The Era 4 textbook provides an explanation for planning your day and week activities, and using a calendar, where you can schedule important appointments and activities. The authors say that through planning, time can be used more effectively, which will allow the student to save it for rest, play, develop interests or for physical activity. The lack of planning can lead to wasted time, for example, while watching TV or computer games for too long. Therefore, authors in a rather original way remind the students to turn the computer on only for specific reasons. The questions under the chapter ask the student to relate to their knowledge and skills regarding the importance of sleep and rest for the health of the body. Authors of the WSiP 4 PzP textbook have written about the benefits of day-to-day planning. An important conclusion in the text is that planning has a positive influence on the lifestyle, which in turn promotes health. Hence, the authors have assigned a very important task to the students to assess their own way of spending free time, whether it is conducive to health and what can be changed for the better. The authors of

13 The following textbooks do not cover these topics: Żak 5, ABC 5, Klett 5, Op 5, WSiP 5, Era 5, WSiP 5 I PzP , WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP, WSiP 6, NE 6.

14 The following textbooks do not cover these topics: 5, ABC 5, Klett 5, Op 5, Era 5, WSiP 5 I PzP , WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP, WSiP 6, NE 6.

the ABC 4 textbook signalled the necessity of activity planning during the day and week in two sentences. They emphasized that proper activity planning allows time for interest development, rest and various everyday activities. There is a very important question for the development of the student's health consciousness about the effects of inappropriate day planning for students' bodies. The authors of the Op 4 textbook devote considerable attention to the need for planning the day and week activities. They share the benefits of proper time management to help you achieve your goals, develop your interests, and find time to rest. The authors also try to convince students how important planning is when organizing trips or travels. The students can also find questions that develop their ability to plan and analyse their schedule, as well as their health awareness. The authors of the Zak 4 and Klett 4 textbooks do not provide reasons for the necessity of planning the day and week activities. The WSiP 4 textbook does not address this issue.

A student using the WSiP 5 textbook can use its content to justify the need for day-to-day planning. It is clear from the text that scheduling daily activities allows us to make use of our time effectively and to spend it developing interests and resting. The authors have published a questionnaire examining pupils' skills related to this problem.

1.5. (...) correctly plans and executes his or her schedule during the day[15]

In the Wiking 4 textbook, the authors provide a table showing the sample day schedule for a fourth grade primary school pupil. Students were asked to plan their work day, which is very important for the development of their skills and health awareness. Also, students who use the book received the task to present interesting ideas for spending their free time. In the Era 4 textbook, students can read the instructions on how to prepare their day plan. Next to the instructions there is also a sample day plan. The authors did not limit themselves to explaining the day's activity planning, but also encouraged the students to create their weekly activity plans. A sample weekly plan is also included in the textbook. In the tasks addressed to the students at the end of the chapter, there is an assignment to create a day plan for tomorrow. The authors of WSiP 4 PzP explain how to plan a day to complete all school and home duties and find time for physical activity, fun, rest and sleep. An example of a day plan in the form of a diagram is included in the textbook, which can be helpful for the student when creating their own. The authors also provided students with suggestions for useful, health-oriented use of their leisure time. They warned young people of violent computer games and TV shows, and making acquaintances through the internet. The question under the chapter refers to the knowledge that is given to the student in the text. It would be helpful for gaining the practical planning and organizing skills if students received a task to arrange a day plan for themselves, which is unfortunately missing in the discussed textbook. The authors of the ABC 4 textbook included three basic principles of good learning organization and some practical tips on how to plan each day. The last two questions at the end of the chapter check the student's ability to plan and execute tasks. The authors of the Op 4 textbook gave out a sample lesson plan for a grade 4 student and posted a question that educates students about how to analyse and draw conclusions. Unfortunately, they did not offer students the task of planning their own activities, for example, for a random day of the week. A student who uses the Zak 4 textbook learns the rules of proper daytime planning. The authors did not, however, include in the textbook any sample activity schedules on which students could model their own. The pupil's ability to plan properly is to be determined by his or her own daily plan, based on the rules provided in the textbook. The authors of the Klett 4 textbook tell you what to look out for to properly plan your daily activities. The last two tasks under the chapter develop the student's practical skills in independently planning their day and the week activities. The authors of the WSiP 4 textbook skipped this issue.

The authors of the WSiP 5 textbook have included a sample 24-hour schedule to encourage students to draw up their own plan. The questions under the chapter do not, however, include such a command.

1.6 (...) applies safety rules during natural observation[16]

The authors of the Era 4 textbook briefly describe the basic safety principles that should be followed during experiments and science observation. They also referred to a situation when students plan the experiments themselves and pointed out the need to consult a teacher or a parent for safety reasons. At the end of the chapter, students will be asked to examine their knowledge of safety during experiments and natural observations. The authors of the WSiP 4 PzP textbook mention safety concerns as a part of experimentation rules, especially when dealing with chemicals that may be harmful to health and doing experiments with fire. In the summary of the chapter and in the questions under the chapter there is no reference to this important content. The authors of the ABC 4 textbook included a naturalist's code that consists of sixteen principles that should be followed by the students during field observations in

15 The following textbooks do not cover these topics: Żak 5, ABC 5, Klett 5, Op 5, Era 5, WSiP 5 I PzP , WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP, WSiP 6, NE 6.

16 The following textbooks do not cover these topics: Wiking 4, Żak 5, ABC 5, Klett 5, Op 5, WSiP 5, Era 5, WSiP 5 I PzP , WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP, WSiP 6, NE 6.

order to preserve their safety and to not destroy the surrounding science. The questions under this chapter are missing any references to these issues. The authors of the Op 4 textbook have omitted the safety issues while describing the principles of natural observation. However, they pointed out that when we learn about science through our senses we do have to be careful – first of all not to sniff on the unknown substances and not to try unknown fruits and mushrooms that can be poisonous. Students do not find any questions under the chapter that would test their knowledge or skills related to this subject. The authors of Żak 4 textbook mention the necessity of maintaining safety while carrying out natural observations outside the school grounds. They emphasize the need for following traffic rules, paying special attention near rivers or lakes, avoiding creating obstacles to others, and following teacher's recommendations. The questions under this chapter do not reference this problem. In the Klett 4 textbook, a student finds notes that it is important to take care of their safety while conducting field observation both in the classroom and in the field. The questions under this chapter are designed to test the students' knowledge and skills. The authors of the WSiP 4 textbook mentioned the need to preserve safety while learning about science through taste and smell senses. These problems were further addressed in the second question, presented under the chapter on page 18.

1.9. recognizes and names some plants (including pots) containing substances that are poisonous or harmful to humans (...)[17]

The authors of the Wiking 4 textbook have taken pictures of poisonous garden and potted plants to help students identify them. The text also mentions dangerous meadow plants and provides pictures of them. Plants that contain narcotic substances used in medicine, that also cause very dangerous addictions that lead to the destruction of the body and death are also mentioned. The authors have included an assignment under the chapter that urges pupils to use sources of information other than the textbook (book about potted plants), to find out which of the potted plants in their house are poisonous. The authors of the Era 4 textbook provided six examples of poisonous plants growing in gardens and parks, three examples of poisonous weeds, and three examples of poisonous potted plants. They put photos of them in the textbook, which allows them to be identified. In the task at the end of the chapter, the authors placed a statement addressed to the students, referring to examples of poisonous plants growing in their environment. The WSiP 4 PzP textbook contains photos of three types of poisonous pot plants that can be found in pupils' homes. The text mentions that there are some plant species growing in parks, gardens, meadows and forests, which are also poisonous, but no photos or names are given within the textbook. It has been explained, however, that the poisonous effects of some plants are due to the juices they produce that are harmful to the body. The question for students, which is addressed under this chapter, tests the knowledge they acquired from the text. The authors did not mention the topic of poisonous plants in the summary of the section. In the ABC 4 textbook a student finds eleven examples of poisonous plants. Thanks to the photos and some short characteristics of each species, it is easy to identify them in the field. The question under the chapter that deals with this topic is reproductive. A student using the Op 4 textbook learns how to handle plants that may contain harmful and even poisonous substances. Unfortunately, the authors did not include any examples of such plants in the textbook. The question under this chapter examines the student's knowledge of how to prevent poisoning while caring for home plants or plants growing under natural conditions. Authors of the Żak 4 textbook have listed examples of poisonous plants that occur in the wild, poisonous domestic plants and poisonous garden plants. They took three photos from each of these groups of plants. In addition, some of the examples of poisonous plants are listed in tables. Unfortunately, under the chapter there were no assignments that check the students' knowledge and skills associated with the curriculum. The Klett 4 textbook provides eight examples of poisonous plants: potted, growing in forests, parks and gardens. The pictures and short descriptions help students gain practical skills in recognizing them in the natural environment. The questions under the chapter are reproductive. The authors of the WSiP 4 textbook provided only two examples of pot plants that are harmful to humans. The photos of these plants allow students to gain the ability to identify them. The students' knowledge of the subject is tested through a question that prompts them to explain why some plants are dangerous to humans.

In the WSiP 6 PzP (part II) textbook, in a chapter entitled „Knowledge recap before middle school", it was recalled that fruits, seeds and flowers of some plants contain poisonous substances, which is why they should be handled with caution. Yew is given as an example.

1.9 (...) provides the rules for dealing with them (some plants, including potted plants, containing substances that are poisonous or harmful to humans. [18]

The Wiking 4 textbook lists two rules for dealing with poisonous plants. One of them says that such spec-

17 The following textbooks do not cover these topics: Żak 5, ABC 5, Klett 5, Op 5, WSiP 5, Era 5, WSiP 5 I PzP , WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6, NE 6.

18 The following textbooks do not cover these topics: Żak 5, ABC 5, Klett 5, Op 5, WSiP 5, Era 5, WSiP 5 I PzP , WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP, WSiP 6, NE 6.

imens should not be located in places that small children and pets have access to. The second one points to the necessity of using protective gloves when replanting and handling. There is no information that these plants should not be eaten and that you should wash your hands even after touching them accidentally. The text briefly describes the health consequences of their consumption. Importantly, recommendations are given as to what to do after a poisonous plant has been eaten. The manual also includes a warning about the milk juice produced by some dangerous plants growing in meadows and fields. In the questions addressed to pupils at the end of the chapter, there was no mention of rules for the poisonous plant treatment. In the Era 4 textbook there are three rules for dealing with poisonous plants growing in gardens and parks. There is no mention of any precautionary principles in the care of poisonous pot plants at home. The questions addressed to students refer to their knowledge in the subject. Authors of the WSiP 4 PzP textbook have informed students about the safety rules to be followed during poisonous pot plants treatment. They also advised caution during walks and advised to avoid direct contact with unknown plants that attract attention through their tasty-looking fruit, beautiful flowers or ornamental leaves. The authors of the textbook did not explain how to behave after consuming poisonous plants. They noted the problem of allergies, caused by some plants' pollen. The question addressed to students under the chapter test their knowledge acquired from the text. In the ABC 4 textbook, a student is to become familiarized with the basic safety principles when encountering poisonous plants. They also learn what to do if one gets poisoned. The student's acquired knowledge is checked by the questions at the end of the chapter that are reproductive. The authors of the Op 4 textbook list four principles for dealing with potted plants and plants growing on meadows or in forests that may be poisonous. The question under this chapter examines the student's knowledge of how to prevent accidental poisoning while handling home plants or plant growing in the wild. Authors of the Żak 4 textbook also provide four principles for dealing with poisonous plants. However, there is no mention of safe handling practices for poisonous plants at home and for young children access limitations. Under the chapter there is one question that examines pupils' knowledge of proper handling of poisonous plants. In the Klett 4 textbook students find practical advice on how to properly cultivate poisonous potted plants. In addition, there is a very important warning against eating very tasty-looking fruits of some poisonous plants. The questions under the chapter tests the students' knowledge and skills, and develops their health awareness. The authors of the WSiP 4 textbook talk about the principles of safety while in contact with poisonous potted plants that may be in the pupil's home. Under the chapter there is a question that examines their knowledge in this field. There are no questions that develop health awareness related to poisonous pot plants that a pupil may have in his home.

Section 5. Man and the environment

5.5 gives examples of positive and negative environmental impacts on human health[19]

The authors of the Wiking 4 textbook discuss the impact of climate factors and environmental pollutants on human health. They described how we can protect ourselves from the negative effects of climate factors on our health. The more serious problem that the authors have mentioned is the environment pollution resulting from industry development, motorway construction and the use of fertilizers in agriculture. Unfortunately, the chapter does not address solutions to this problem, omitting, for example, the topic of organic farming. The textbook shows how the harmful substances get from the environment to the human body by using a scheme. The chapter includes questions about the student's knowledge and skills related to the topic. In the ABC 4 textbook, we can find some information about the negative impact harmful substances found in the environment have on human health. The authors also mention diseases that may be caused by coming in contact with them. The course book devotes a lot of attention to the negative impact of noise on human health, but the topic of the positive impact of science contact on our mental and physical health is omitted. The questions under the chapter are very general and reproductive. The authors of the Op 4 textbook list and briefly describe examples of environmental factors that have positive and negative effects on our health. Among the positive factors they highlight the importance of outdoor walks, spa visits, bathing in natural healing waters, staying in the sun, and proper nutrition. The student is also provided with some examples of the negative impact of polluted environment on human health. In addition, the authors mention the destructive impact of noise on human health. The questions listed below only test the student's knowledge. The authors of the Żak 4 textbook completely ignored all the aspects related to the positive impact the environment has on human health. On the other hand, they devoted much of their attention to the problem of human activity, which leads to pollution of the natural environment, which in turn causes many serious diseases. These diseases were not mentioned by the authors of the textbook. In the Klett 4 textbook, the topic of positive environmental impact on human health has been completely omitted. In the chapter

19 The following textbooks do not cover these topics: Era 4, WSiP 4 PzP, Żak 5, ABC 5, Klett 5, Op 5, WSiP 5, Era 5, WSiP 5 I PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, Żak 6, WSiP 6 PzP, WSiP 6, NE 6.

devoted to the human activity's impact on the state of the natural environment we find only a brief mention of the dangerous effect of smog on human health and the relationship between the occurrence of ozone holes in the atmosphere and the increased development of skin cancer. There are no questions under the chapter or in the repetition section of the chapter about the issues related to the discussed topic. The authors of the WSiP 4 textbook explained what living in harmony with science means. They emphasized the importance of human contact with science and healthy eating. They also referred to the problem of so-called organic farming. Under the chapter, they ask questions that shape the students' health consciousness, prompting them to wonder if they live in harmony with science.

The WSiP 5 II PzP textbook mentions the negative impact of air, water and soil pollution on the human body. However, the positive impact of the contact with natural environment and science on mental and physical health has been neglected.

10. Electrical and magnetic phenomena in science

10.4 ... describes (...) the principles of safe handling of electrical appliances; (...) applies the principles of safe handling of electrical appliances[20]

The authors of the Era 4 textbook listed three safety rules that must be followed while handling household electrical appliances. There are no rules for removing a plug of the electric appliance with wet hands, as well as for the use of electrical appliances, such as a hair dryer in the vicinity of a bath filled with water or a shower. There was also no description, how to safely replace a lightbulb. The question under the chapter aims to check the student's knowledge contained in the text. A student who uses the WSiP 4 PzP textbook is familiarized with the four principles of safety in using electrical appliances at home. In this textbook there is also no warning against disconnecting electrical plugs from power sources with wet hands. Pictures of electrical equipment bearing appropriate indications help students understand the safety rules of electrical equipment handling. The topic was not mentioned in the chapter summary. The questions under the text are reproductive.

The rules for safe handling of electrical equipment were described in Section 7, entitled "Electrical, Magnetic and Acoustic Phenomena in Nature", in the two chapters: 7.4. "Electricity – its sources and uses" and 7.7. "Safe use of electrical appliances". In chapter 7.4. the authors have provided information on how to properly connect the power supply to everyday devices such as vacuum cleaners, electric kettles, and electronic devices such as computers or printers, taking into account the voltage required on the rating plates of the devices. The text also explains why the knowledge of voltage is very important for the safe use of electrical appliances. The student learns that the effects of using a voltage that is too high can even result in the device becoming ignited. In the next sentence, the need to familiarize oneself with the voltage value requirements the devices is highlighted.

The text is diversified with several pictures of nameplates showing the voltages required by different electrical devices. It is important, because the theoretical knowledge can be immediately verified and used in practice by the student. This command is written in bold and italics, and aimed at the practical application of the knowledge acquired by the student by checking the voltage values specific to the electrical devices in the student home. The rules for safe use of electrical appliances are described in chapter 7.7. Specific rules are listed in a uniform text without any drawings or illustrations, which would certainly have a greater impact on the students' imagination, as well as their health awareness. In addition, some principles are described very broadly and are not supported by concrete examples of behaviour to be applied in everyday life. For example, there is no mention that you should not use electrical appliances, such as hair dryers, in the immediate vicinity of water, i.e. near a bathtub or a sink filled with water. This chapter deals with the very important issue of the possible consequences of actions that are reckless and incompatible with electrical safety regulations – namely electric shocks. A student learns that electric shocks can cause serious health issues such as burns or even a heart attack. The next sentence deals with giving first aid to a person who has suffered an electric shock, with the concern for their own safety. However, the students are only told how to that by commanding them to disconnect the power supply and call for help as soon as possible. The concern for the condition of the natural environment is a very important element of taking care of our own health and the health of others. Therefore, the authors rightly point out that electrical appliances contain a lot of substances that are harmful to the environment, hence it is necessary to properly recycle them when they are no longer used. Picture 260 captioned "Waste batteries should be disposed of in special containers" on page 146 plays a role in encouraging students' to responsible and informed conduct with waste electrical or electronic equipment. Questions that are addressed at the end of the chapter, asking for specific student activities in their school that are related to the collection of waste batteries and electrical appliances are helpful in shaping the students' awareness and attitude. The pupil's competency test at the end of the chapter only relates to the student's knowledge. However, to raise the level of health education the tasks that appeal to the student's skills and health awareness would also be helpful. The issue of safe use of electrical equipment

20 The following textbooks do not cover these topics: ABC 4, Wiking 4, Op 4, Żak 4, Klett 4, WSiP 4, ABC 4, Wiking 5, Era 5, WSiP 5 II PzP, Wiking 5, Op 6, Wiking 6, Klett 6, ABC 6, WSiP 6 PzP.

seems to be significant enough that it would also deserve more attention in the summarization at the end of the chapter. The topic of safe handling of electrical equipment is described in chapter V of the ABC 5 textbook entitled "Electrical and magnetic phenomena in science". Household electrical appliances are described in the picture on page 205 in Chapter 2: "What is electric current?" This chapter also includes a photo of a marked container in which the used batteries should be stored. The photograph is accompanied by a brief note on the danger of the substances from which batteries and accumulators are built. In the next chapter of the handbook – "Though which substances a current flows?" – there are ten principles of safe use of electrical equipment and seven steps of first aid to a person experiencing electric shock. The essential information is provided by the authors in a tangible way. Of the eight questions at the end of the chapter "Though which substances a current flows?" only the last two are related to the safety issues of electrical appliances. It should be noted that none of them refer to the skills or health awareness of students. It is intended only for students to reproduce the knowledge acquired in this chapter. Another grade 5 textbook – Klett 5 lists six principles for safe use of household electrical appliances in Chapter 31, entitled "Safe at work and during rest". Some appropriate and inappropriate behaviour related to this problem is depicted on the attached photos. The authors also point out how to behave when first aid is needed for a person shocked by electricity, but also about their own safety. Of the five questions at the end of the chapter, only one refers to the knowledge about the use of electrical appliances. It should be noted that the authors of the textbook remind of the safety rules in the summary at the end of the chapter. These issues are also addressed in Chapter 34, entitled "How does electricity work?". The authors point to this important topic in one sentence, and then refer to the knowledge that the students have already acquired. Among the questions that examine the student's acquired competences, at the end of this chapter, the last question relates to their ability to maintain safety while handling electrical power. However, in the chapter summary, this issue is completely omitted. In the Op-5 textbook, the issue is discussed in Chapter 5.2: "Safe and dangerous effects of electric currents." A drawing in which a boy named Michał wants to share his knowledge and skills on safe use of electrical appliances with his peers and siblings at the beginning of a chapter may play a prominent role in the development of health awareness among children learning in grade 5. However, this interesting way to familiarize students with these issues, which seems to involve the child's emotions in the process of acquiring knowledge and skills, is not continued throughout the chapter. The authors of the textbook present seven recommendations that must be followed when using electrical equipment, which is a fairly standard outlook. These recommendations are provided in a language that is accessible to and understood by 5th grade students. A warning, accompanied by an exclamation point and printed in a different colour, alerting of a possible lethal danger of electricity from using an appliance in close proximity to the water, which is a good power conductor can definitely effect the child's imagination and emotion. One of the questions asked in the homework section tests the student's ability by indicating the situation in which the current can be dangerous to human health or life. The issue of safe use of electrical equipment has not been found in the knowledge summary at the end of the chapter. The WSiP 5 textbook lists several principles for safe use of electrical appliances. Some of them are presented in the form of illustrations, with appropriate descriptions. Students also have the opportunity to conduct and experiment testing whether a salt solution conducts electricity. Based on the experiment, they should conclude that using a hair dryer during bathing may cause an electric shock. The authors of the WSiP 5 I PzP textbook have listed six principles of safe use of household electrical appliances. Particular attention has been paid to the bathroom safety and to the situations in which we may be endangered by electric shocks. They have proposed an experiment to prove that water conducts electricity well. Therefore when we take baths, stand on a wet floor or have wet hands, we should not use electrical appliances. Two questions that test the students' knowledge and skills reflect on the safe use of electrical appliances in the bathroom – they are located under the chapters that discuss this topic: "The effects of an electrical current" and "Electricity in my home". The authors of the Żak 6 textbook give some principles of safe use of electricity. The text is accompanied by a single photo, which is intended to warn against careless handling of electrical sources. The questions under this chapter apply very broadly to all the dangerous situations that a student may encounter at home. In the WSiP 6 textbook, the problem was mentioned in one of the questions in a chapter that aims to recap information before middle school. The NE 6 textbook briefly informs students how to safely use electrical equipment. Under this chapter, the authors did not mention these issues.

Summary and Conclusions

It is difficult to overestimate health and its proper place in social life and in the life of the individual. The topic of health appears in the proverbs and in everyday discussions for both children and adults (Kirschner, 1992). Cisek and colleagues report that the level of health care depends on the level of education and a higher level of health awareness hence the level of education, occupation and social position is important

#	Recording content	Publishing house label according to table 4																										
		Wiking			Nowa Era 1			Operon			LektorKlett			WSiP 1			Nowa Era 2			Żak			ABC			WSiP 2		
		1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	5.1	5.2	5.3	6.1	6.2	6.3	7.1	7.2	7.3	8.1	8.2	8.3	9.1	9.2	9.3
1. Me and my surroundings. Student:																												
1	lists positive and negative influences on his or her well-being at school and at home (...)		■		■			■			■			■			■			■			■			■		
	(...) suggests ways of eliminating negative factors		■		■			■						■			■			■			■			■		
2	explains the importance of rest (including sleep), nutrition and physical activity in the proper functioning of the body		■					■	■		■	■			■			■		■		■	■	■		■	■	■
3	lists the principles of correct learning (...)	■			■			■			■			■			■			■			■			■		
	(…) applies them in life	■			■			■			■			■			■			■			■			■		
4	describes a properly designed learning place (…)	■			■			■			■			■			■			■			■			■		
5	explains to the need to plan day and week activities (...)	■			■			■			■				■		■			■			■			■		
	(...) correctly plans and executes his or her schedule (…)	■			■			■			■			■	■		■			■			■			■		
6	(...) applies safety rules during natural observation				■		■	■	■		■			■			■			■			■			■		
9	recognizes and names some plants (…) containing substances that are poisonous (...)	■			■			■			■			■			■			■			■			■		
	(...) provides the rules for dealing with them	■			■			■			■			■			■			■			■			■		
5. Man and the environment. Student:																												
5	gives examples of (…) environmental impacts on human health	■	■	■	■	■	■	■					■	■			■			■			■			■	■	
10. Electrical and magnetic phenomena in nature. Student:																												
4	(...) describes and applies the principles of safe handling of electrical appliances		■				■		■			■			■	■	■		■		■	■		■		■	■	

Table 5: Summary of the presence of specific content in the analysed textbooks

Grey indicates that this content was present in the textbook of the series

(Cisek, Gniadek, Richter, Chmiel, 2004). Nowadays, in times of rapid technological development, unrestricted access to information and ubiquitous information clutter on the Internet (Tadeusiewicz, 1999) many people are trying to diagnose and cure themselves. This problem affects both adults and teenagers. In addition, it is worth noting that for many different reasons, anti-vaccination, homeopathic, bioenergy therapy or bioenergy healing and other types of "natural" treatment are becoming more and more popular nowadays.

In society (and also among children), there are many inaccuracies or misconceptions regarding health information. An analysis of interviews conducted with students from several secondary schools by Dr. Barbara Ostrowska from the Educational Research Institute, concerning the didactic tool presented below[21] (teaching tool – drug leaflet) pose as an interesting example of it.

The following are excerpts from the information leaflet of a drug.

> ***Description of action: the drug has anti-inflammatory, bronchodilatory and antiallergic properties.***
> ***Instructions of use:***
> *- acute and chronic inflammation of the upper and lower respiratory tract,*
> *- bronchospasm,*
> *- otitis media.*
> ***Side effects:***
> *- gastrointestinal disorders, nausea, abdominal pain,*
> *- drowsiness,*
> *- speed up heart function.*

After a few days of using the presented medication, Ania experienced vomiting and abdominal pain. Rate the truth of the following statements by circling T – True or F – False.

No.	Statement	True or false
1.	The girl's malaise may be a side effect of taking a medicine.	T / F
2.	Ania may have food poisoning.	T / F

Interviews were conducted to define what made it difficult for the students to solve the problem posed by the question. Interviews show that:

- The task introduction was not a problem, and students mostly answered correctly to the first questions.
- Interestingly – students do not identify the girl's malaise with abdominal pain and vomiting. **In their opinion it is not based on physical symptoms**. Thus, there is a misunderstanding of a (seemingly very simple and basic) concept of *well-being* that often appears in science textbooks in elementary school. It is most likely that the authors of the textbooks considered the concept to be so obvious that it does not need explaining.

Due to the aforementioned problems, the need for shaping health awareness among children seems to be more and more important. Stawiński states that: *(...) from the very beginning of their education pupils should be aware of the need to care for their own health and the importance of hygienic practices. In parallel with mastering the necessary knowledge and skills, students should actively participate in acquiring habits and attitudes. A personal example, strong will and the ability to resist negative peer and elders' pressure (...) play a very important role in this* (Stawiński, Walosik 2006). It is of utmost importance to place particular emphasis on the relevant provisions for shaping awareness and pro-health behaviour in educational documents. The publication details the 2009 and 2017 curriculums in terms of the preamble content as well as the learning objectives and content of the subjects taught in Science and Biology. Most records are repeated or highly compatible (Table 3). From the point of view of health records, the main difference between the curriculums is that some of the sub-points are disposed from the science curriculum to the science and biology (5-8) subjects in elementary school[22]. Of course, the provisions in educational documents will not themselves guarantee adequate education for children and young people. the role of teachers in the teaching-learning process is extremely important. [23] Documents should, however, work as a guarantee that relevant records will be present in school textbooks. Of course, the presence of textbooks in school and for student self-study can be assessed both positively and negatively – this issue was not the subject of the publication. The problem of the presence of textbooks in school classes has been dealt with for many years by educators and researchers (Stasińska, 1983, Drynda 1998). The study, however, shows that the textbook, regardless of its form – paper or electronic – has been the basis of school education for many years (CNK, 2009). In an adequate report from the Educational Research Institute's Natural Sciences Institute: *Diagnosis of primary school science teachers' needs for support, in conducting lessons, the research methodology* shows that almost 90% of teachers use textbooks in each lesson. *The teachers who*

21 Unpublished material, courtesy of Dr. Barbara Ostrowska from the Educational Research Institute. The analysis was carried out on 24 pupils and was related to a larger group of tools. In this task only 10 students answered correctly to both lines of the task.

22 It is important to emphasize the importance of student's health awareness in the process of introducing new textbooks into primary schools.

23 According to the results of the IBE (Educational Research Institute) study: in practice students are not taught from ministerial documents but according to the school-adopted curriculum and using specific textbooks (IBE, Grajkowski, Ostrowska, Studzińska 2013).

work in the field for over 14 years more often declared that the situation ([...] where students work individually with a textbook or exercise book) takes place almost in every lesson (IBE, Grajkowski 2014). Accordingly, it seems that the analysis of textbooks according to the aforementioned aspects is an important aspect in shaping healthy behaviours for future conscious citizens.

Based on the analysis of the textbooks mentioned in the chapter: Material and Methods, we can draw conclusions about the influence of these didactic measures on shaping the health awareness of elementary school pupils in science classes. All analysed textbooks may influence the student's health consciousness. It should be noted, however, that this effect is strongly differentiated in terms of frequency and types of tasks and activities proposed to students. Textbooks are usually focused on giving and describing concepts and providing definitions. There are also a number of exercises and tasks that shape skills and serve to reproduce information. All these competences are extremely important and are included in the core curriculum, but the need to shape the health consciousness of students is unfortunately often marginalized. It is worth to compare 20 examples of tasks taken from four randomly selected textbooks for teaching science in grade 4 from the sections related to 1.1 record of the core curriculum for the subject Nature 1.1: *lists positive and negative influences on his or her well-being at school and at home and proposes ways to eliminate the negative ones*.

1. Write in two columns: the elements of your surroundings that are essential to your life, and the things that make life easier for you [Żak 4].
2. Count how many litres of water you drink per day (including: tea, soup, juices, mineral water and other liquids). Determine whether this quantity is sufficient [Żak 4].
3. List your actions that promote family bond development [Żak 4].
4. What are your feelings about the school and its surroundings? Write down what you would like to change [Żak 4].
5. List the positive and negative influences that affect your well-being at school and at home. [Żak 4].
6. Replace bad and favourable learning conditions [Skill 4].
7. Make your own schedule using the rules for proper scheduling. [Żak 4].
8. List the basic principles of learning [Klett 4].
9. Describe your place of study and assess whether it is properly designed. [Klett 4].
10. Explain the importance of rest (including sleep) for proper functioning of the body [Klett 4].
11. Plan your activities for one study day [Klett 4]
12. Plan your activities throughout the week, i.e. 7 days, including days off [Klett 4].
13. Suggest some sentences ending for: *I like school because ...* [NE 4].
14. Give examples of dangerous behaviour at school [NE 4].
15. Explain what a place to study at home should look like [NE 4].
16. List the principles of effective learning [NE 4].
17. Propose how you can help a shy person [WSiP 4].
18. Explain what you can do to be liked by others [WSiP 4].
19. Describe how you can help a person with a disability and how they can help you [WSiP 4].
20. Determine how to behave in order to feel good at school [WSiP 4].

Of course, the tasks presented are only a small part of the tasks placed in all the textbooks. As an example, however, they show that some commands (e.g., 2, 4, 5, 7, 8, 11, 12, 18, or 20) can influence the shaping of health awareness and of healthy lifestyle in particular by understanding how our simple, daily activities impact our health[24]. *Health awareness includes general* ***knowledge about factors and behaviours affecting health, and indirectly also our opinions on our influence on our health****, motivation and ability to make pro-health choices* – as suggested by Cisek. This is consistent with the definition given by Mazurkiewicz (Mazurkiewicz, 1978) and quoted by Korzeniowska (Korzeniowska, 1997) *(...) among the definition of health behaviours are those which include* ***the consciousness of the acting subject*** *within a concept of behaviour. [...] E. Mazurkiewicz understands all behaviours / habits, customs, attitudes, values recognized by individuals and social groups / in the field of health as health behaviours.*

All of the science textbooks for the second stage of education included in the study can be used to implement the assumptions of the core curriculum for general education. The content discussed in each textbook is exhaustive of the document, and often extends on it. [25].

Students' health awareness manifests itself when they make a reflective analysis of various problem situations that are present in the textbook (Chrzanowski, Gawrońska, Aszklar, Piszczek, 2016). This awareness is often a reflection of their personal experience. While conducting this type of reflection a student can gain awareness of the value of healthy behaviour connected with even the simplest activities they perform during the day. This is certainly the foundation of the acquired knowledge and skills related to health in our own system of values.

24 Some of these tasks, unfortunately, were reproductive, as they referred to the text or illustrations in the textbook.

25 It is worth noting that most textbooks deal with issues discussed in the publication in textbooks for grade 4 of primary school (Table 5).

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Appendix 1. List of abbreviations used to describe textbooks

Code and number of the textbook	Series title	Authors	Publishing house
ABC 4 8.1	Przyroda	B. Gulewicz, B. Brzozowska-Michałek, A. Lauda-Michalska, J. Piętka-Baumgart, B. Ziółkowska	ABC
Op 4 3.1	Ciekawi świata 4 Przyroda	Małgorzata Augustowska, Małgorzata Gajewska	Operon
Klett 4 4.1	Przyroda z klasą	Joanna Buniowska, Ewa Frąckowiak, Ewa Gęca, Przemysław Jeruszka	LektorKlett Poznań
WSiP 4 PzP 9.1	Przyroda z pomysłem część I i II	Urszula Depczyk, Bożena Sienkiewicz, Halina Binkiewicz	Wydawnictwa Szkolne i Pedagogiczne
Wiking 4 1.1	Przyroda poznać i zrozumieć	Brygida Baranowska, Elżbieta Szedzianis, Robert Wers, Romana Woźnik	Wiking
WSiP 4 5.1	Przyrodo, Witaj!	E. Gromek, E. Kłos, W. Kofta, E. Laskowska, A. Melson	Wydawnictwa Szkolne i Pedagogiczne
Era 4 6.1	Na tropach przyrody	Marcin Braun, Wojciech Grajkowski, Marek Więckowski	Nowa Era
Żak 4 7.1	Przyroda	B. Klimuszko, J. Sokołowska, M. Wilczyńska-Wołoszyn	Żak Wydawnictwo Edukacyjne Zofii Dobkowskiej
ABC 5 8.2	Przyroda	Barbara Gulewicz, Anna Lauda-Michalska, Joanna Piętka-Baumgart, Beata Ziółkowska	ABC
Op 5 3.2	Ciekawi Świata 5 Przyroda	Małgorzata Augustowska, Elżbieta Bytniewska, Małgorzata Gajewska, Marzena Karwowska	Operon
Klett 5 4.2	Przyroda z klasą	Ewa Frąckowiak, Ewa Gęca, Joanna Buniowska	LektorKlett Poznań
NE 5 2.2	Tajemnice Przyrody	Janina Ślósarczyk, Ryszard Kozik, Feliks Szlajfer	Nowa Era
WSiP 5 I PzP 9.2	Przyroda z pomysłem Część I	Urszula Depczyk, Bożena Sienkiewicz, Halina Binkiewicz	Wydawnictwa Szkolne i Pedagogiczne
WSiP 5 II PzP 9.2	Przyroda z pomysłem Część II	Urszula Depczyk, Bożena Sienkiewicz, Halina Binkiewicz	Wydawnictwa Szkolne i Pedagogiczne
Wiking 5 1.2	Przyroda poznać i zrozumieć	Brygida Baranowska, Elżbieta Szedzianis, Robert Wers, Romana Woźnik	Wiking
WSiP 5 5.2	Przyrodo, Witaj!	Ewa Gromek, Ewa Kłos, Wawrzyniec Kofta, Ewa Laskowska, Andrzej Melson	Wydawnictwa Szkolne i Pedagogiczne
Era 5 6.2	Na tropach przyrody	Marcin Braun, Wojciech Grajkowski, Marek Więckowski	Nowa Era
Żak 5 7.2	Przyroda	Berenika Targos-Panak, Maria M. Wilczyńska-Wołoszyn	Żak Wydawnictwo Edukacyjne Zofii Dobkowskiej
Op 6 3.3	Ciekawi Świata 6 Przyroda	Małgorzata Augustowska, Elżbieta Bytniewska, Małgorzata Gajewska, Marzena Karwowska	Operon
Wiking 6 1.3	Przyroda poznać i zrozumieć	Brygida Baranowska, Elżbieta Szedzianis, Robert Wers, Romana Woźnik	Wiking
Klett 6 4.3	Przyroda z klasą	Ewa Frąckowiak, Ewa Gęca, Joanna Buniowska	LektorKlett Poznań
ABC 6 8.3	Przyroda	B. Gulewicz, A. Lauda-Michalska, J. Piętka-Baumgart, B. Ziółkowska	ABC
Żak 6 7.3	Przyroda	L. Bober, B. Targos-Panak, M. Wilczyńska-Wołoszyn	ŻakWydawnictwo Edukacyjne Zofii Dobkowskiej
WSiP 6 PzP 9.3	Przyroda z pomysłem część I i II	Urszula Depczyk, Bożena Sienkiewicz, Halina Binkiewicz	Wydawnictwa Szkolne i Pedagogiczne
WSiP 6 5.3	Przyrodo, Witaj!	E. Gromek, E. Kłos, W. Kofta, E. Laskowska, A. Melson	Wydawnictwa Szkolne i Pedagogiczne
NE 6 2.3	Tajemnice Przyrody	Joanna Stawarz, Feliks Szlajfer, Hanna Kowalczyk	Nowa Era

