

# AWARENESS OF PERFLUORINATED ALIPHATIC COMPOUNDS (PFAS) IN THE YOUTH POPULATION OF SWIETOKRZYSKIE PROVINCE

## ŚWIADOMOŚĆ MŁODZIEŻY WOJEWÓDZTWA ŚWIĘTOKRZYSKIEGO W ZAKRESIE PERFLUOROWANYCH ZWIĄZKÓW ALIFATYCZNYCH (PFAS)

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### SUMMARY

**Background:** Socio-economic development causes the pollution of environment with many harmful chemicals. A number of contaminants are characterised by high toxicity, persistence in the environment, and the ability to cumulate in organisms and, moreover, by biomagnification in the food chain. The perfluorinated aliphatic compounds (PFAS), present in each part of the environment, in food and used in production of many everyday objects, are an example of such substances. People are exposed to PFAS by ingestion and inhalation, as well as through the dermal route. These compounds constitute significant health risk factors for the society.

**Aim of the study:** The aim of this study was to evaluate the awareness of the perfluorinated aliphatic compounds (PFAS) in the population of youth from Swietokrzyskie province.

**Materials and methods:** The research was conducted in Swietokrzyskie province. The study population consisted of 366 students from secondary schools, aged between 16 and 20 years old. The research was performed using a questionnaire containing eight multiple-choice questions. The awareness of respondents was analysed based on the answers to questions on the properties of perfluorinated aliphatic compounds, sources of exposure to these substances, possible routes of exposure, health effects resulting from the exposure to these xenobiotics and possible methods of minimising the exposure.

**Results:** The results of the study indicate low awareness young people have of the perfluorinated aliphatic compounds. The young people in Swietokrzyskie province (74.7%; N = 274) do not know if they had ever been exposed to PFAS. 86.4% (317) of respondents are not able to name the basic features of these compounds, and 83.1% (305) are not aware of their use. Most of the students (80.6%; N = 296) do not know the health effects resulting from exposure to PFAS.

**Conclusions:** The awareness of perfluorinated aliphatic compounds (PFAS) in the population of students from secondary schools in Swietokrzyskie province is very poor. Therefore, there is a need to conduct information campaigns addressed to all social groups, especially children and young people of school age.

**KEYWORDS:** perfluorinated aliphatic compounds, awareness, health risk

## STRESZCZENIE

**Wstęp:** Rozwój społeczno-gospodarczy jest powodem zanieczyszczenia środowiska wieloma szkodliwymi związkami chemicznymi. Szereg zanieczyszczeń charakteryzuje się silną toksycznością, trwałością w środowisku, zdolnością kumulacji w organizmach roślin i zwierząt, ponadto ulegają one biomagnifikacji w łańcuchach pokarmowych. Przykładem takich substancji są perfluorowane związki alifatyczne (PFAS), które są obecne w każdym elemencie środowiska, w żywności, a także stanowią składnik wielu przedmiotów codziennego użytku. Narażenie na PFAS jest powszechne, zachodzi zarówno pokarmową, oddechową, jak i dermalną drogą narażenia. Związki te stanowią istotny czynnik ryzyka zdrowotnego współczesnego społeczeństwa.

**Cel pracy:** Celem pracy była ocena stanu wiedzy młodzieży województwa świętokrzyskiego w zakresie ryzyka zdrowotnego, wynikającego z narażenia na perfluorowane związki alifatyczne.

**Materiał i metody:** Do badania zakwalifikowano 366 osób w wieku 16–20 lat uczęszczających do szkół ponadgimnazjalnych w województwie świętokrzyskim. Narzędzie badawcze stanowił autorski kwestionariusz ankiety, który zawierał 8 pytań wielokrotnego wyboru. Stan wiedzy ankietowanych oceniono na podstawie pytań dotyczących właściwości perfluorowanych związków alifatycznych, źródeł narażenia na PFAS, możliwych dróg przenikania do organizmu, efektów zdrowotnych wynikających z narażenia na te związki oraz sposobów umożliwiających ograniczanie narażenia na PFAS.

**Wyniki:** Wyniki przeprowadzonego badania wskazują na niską świadomość młodzieży dotyczącą perfluorowanych związków alifatycznych. Badana młodzież województwa świętokrzyskiego (74,7%; N = 274) nie wie, czy kiedykolwiek była narażona na PFAS. Ponadto 86,4% (317) respondentów nie potrafi wskazać podstawowych źródeł narażenia, a 83,1% (305) nie jest świadoma zakresu zastosowania tych związków. Zdecydowana większość uczniów (80,6%; N = 296) nie zna następstw zdrowotnych wynikających z narażenia na PFAS.

**Wnioski:** Wiedza młodzieży województwa świętokrzyskiego na temat perfluorowanych związków alifatycznych jest znikoma. Wysoce uzasadniona jest potrzeba prowadzenia kampanii informacyjnych skierowanych do wszystkich grup społecznych, a zwłaszcza do dzieci i młodzieży w wieku szkolnym, w zakresie zagrożeń zdrowotnych związanych z PFAS.

**SŁOWA KLUCZOWE:** perfluorowane związki alifatyczne, świadomość, ryzyko zdrowotne

## BACKGROUND

Socio-economic development causes the pollution of environment with many harmful chemicals. A number of contaminants are characterised by high toxicity, persistence in the environment, and the ability to cumulate in living organisms and, moreover, by biomagnification in the food chain. The perfluorinated aliphatic compounds (PFAS), present in each part of the environment, in food and used in production of many everyday objects, are an example of such substances [1].

Perfluorinated compounds are derivatives of aliphatic, cyclic, polycyclic hydrocarbons, in which most or all of the hydrogen atoms have been replaced with fluorine atoms. An example of perfluorinated compounds, which are considered the most common in the environment are: perfluorooctanesulfonic acid (PFOS), perfluorooctanesulfonamide (PFOSA) and perfluorooctanoic acid (PFOA) [1–2]. Strong covalent carbon-fluoride bonds are formed in the perfluorinated aliphatic hydrocarbon particles. The compounds are not biologically inert, and their toxicity is very high. Moreover, these compounds are persistent and resistant to biodegradation, high temperatures, chemical and biological agents. PFAS are at the same time both hydrophobic and hydrophilic. They cumulate and

biomagnify in living organisms, which is negative in terms of exposure. The PFAS cumulate in tissue of fish, birds and mammals connected with the aquatic food chain. Studies have shown that these xenobiotics are present in surface water in lakes, rivers, seas and oceans [3–6].

The danger caused by exposure to these compounds depends on their ability to permeate to the body through each route of exposure: inhalation, ingestion and dermal. A person can be exposed to PFAS by eating animal products and drinking water. They can also enter the body via lungs and skin from many everyday products, such as: furniture, floors, clothes, etc. One of the sources of PFAS exposure are the inhaled particles of dust [3–4, 7].

Perfluorinated compounds have been synthesised for over 50 years. Their properties allowed them to find broad application in objects of everyday use, inter alia impregnations for floor coverings, leather and leather-like materials, carpets, furniture, natural and synthetic (e.g. Goretex) fabrics, upholstery, paper, cardboard, and food packaging. The usable area of a product enriched with perfluorinated compounds is resistant to water solutions, oils, fats and grease. This prevents the surface from soiling, as it is not adhesive for hydro- or lipophilic water, fat and dust parti-

cles. PFAS are also the elements of medical equipment, reagents used in photography, conditioning agents for floors and furniture, fire retardant additives, some kitchen utensils (component of Teflon). In transformers they are used as substitutes for polychlorinated biphenyls. Moreover, they are added to paints, air fresheners, and even cosmetics [7–10]. They are also used in the production of grease-resistant food packaging materials. Storing food in such packaging constitutes a risk of contamination with PFAS particles permeating food.

Data on the health risks caused by exposure to PFAS are currently limited. The few epidemiological studies do not allow to unambiguously show statistically significant correlation between exposure and health problems. However, it is suspected that these compounds can increase the risk of bladder cancer. Animal studies show that PFAS have, *inter alia*, hepatotoxic and teratogenic effects. It is believed that even small doses of these substances can interfere with reproductive functions and have negative effects on the development of the foetus. Furthermore, they interfere with thyroid functions and fatty acid metabolism. They can also negatively affect the immune system and neurohormone functions [4, 9, 11].

Currently perfluorinated aliphatic compounds are the subject of extensive toxicological and epidemiological studies. The existing studies conducted on animals and employees exposed at work unambiguously show that these compounds are not inert to the human body and their particular characteristics, such as: persistence, the ability to cumulate, resistance to biodegradation, cause them to constitute serious health risks [1, 10–11]. Therefore, it is essential to expand the knowledge on health risks arising from PFAS exposure, as it will allow the development of effective prophylaxis and the limiting of the exposure. Thus, the aim of this paper was to assess the awareness of youth of the health risks arising from exposure to perfluorinated aliphatic compounds (PFAS).

## AIM OF THE STUDY

The aim of this study was to evaluate the awareness of the perfluorinated aliphatic compounds (PFAS) in the population of youth from Swietokrzyskie province.

## MATERIAL AND METHODS

### Selection of the Study Group

The study population constituted of 366 students, 210 (57.2%) boys and 156 (42.8%) girls, from secondary schools, aged between 16 and 20 years old. Most of the respondents (71.9%) were residents of rural areas and 27.8% were residents of cities. The highest number of the respondents (56.7%) were students of high schools. Students of technical schools and vocational schools constituted 22.3% and 20.7%, respectively.

## Research Tool

The research tool was an own questionnaire, consisting of 8 multiple-choice questions on the properties of perfluorinated aliphatic compounds, sources of exposure to these substances, possible routes of exposure, health effects resulting from the exposure to these xenobiotics and possible methods of minimising the exposure. The questionnaire was anonymous, conducted in the presence of a teacher or a researcher.

The collected data were entered into an Excel spreadsheet and then exported to STATISTICA 10.0, StatSoft Poland. The results were presented in graphs.

## RESULTS

The results of the study indicate low awareness young people have of the perfluorinated aliphatic compounds. The students from Swietokrzyskie province (74.7%; N = 274 of the study population) have no knowledge of the presence of PFAS in their everyday life. Only 9.81% (36) know that they have ever been exposed to perfluorinated aliphatic compounds [Figure 1]. The fact that the vast majority of the respondents (86.4%; N = 317) do not know the basic sources of exposure to these compounds is disconcerting. Young people are not aware that these compounds are present in food, dust and clothes [Figure 2]. The respondents (83.1%; N = 305) declared a lack of knowledge on the applications of PFAS [Figure 3]. The vast majority of the respondents (83.6%; N = 307) could not name a single characteristic of the compounds and only 10.6% (39) believed them to be toxic [Figure 4]. Most of the respondents (73.6%; N = 270) did not know the routes of exposure to PFAS. Only 19% (73) of the respondents believed the route to be inhalation, and the ingestion and dermal routes were indicated by 8.2% (30) and 8.9% (33), respectively [Figure 5]. The respondents (80.6%; N = 296) were not aware of the health risks associated with PFAS exposure. Only 11.4% (42) indicated PFAS as a possible cause of cancer, and as little as 3.3% (12) indicated PFAS can interfere with reproductive functions [Figure 6]. The respondents (81.7%; N = 300) were not aware of any measures limiting exposure to PFAS [Figure 7].

## DISCUSSION

PFAS are components of almost all objects of everyday use, which means that it is close to impossible to eliminate exposure. However, it is possible to try and limit the volume of the compounds entering the body [8, 11–12]. Thus, we attempted to assess the awareness the youth from Swietokrzyskie province has of perfluorinated aliphatic compounds. The result of the present study show that the youth from Swietokrzyskie province has no knowledge of ever being exposed to PFAS, cannot name the basic sources of exposure and is not aware of the applications of these compounds. In a similar study conducted on a population of adult residents of Slaskie province, 69.3% (291) of the respondents could not name a single source of exposure to PFAS [13].

Being aware of the sources of PFAS exposure is essential, as it will allow the society to consciously minimise exposure to these xenobiotics.

The present study conducted in Swietokrzyskie province showed that young people have no knowledge on the characteristics of perfluorinated aliphatic compounds. The vast majority of the respondents could not characterise these substances correctly. The results of the Slaskie study are slightly better, with 31% of the respondents declaring PFAS as dangerous to the human body. However, similarly as with the present study, over half of the population (61.4%;  $N = 258$ ) could not name the basic PFAS characteristics [13].

Even though these compounds were still considered safe and not posing any risks to humans and the environment in 1990, the most recent publications show that PFAS are not biologically inert, but rather toxic and resistant to biodegradation. The results from a WWF (World Wildlife Fund) study conducted in Poland confirmed that the human body, as one of the elements of the environment, accumulates the same pollution which can be detected in water, food, air, and everyday objects [3, 14–15].

In the present study, the majority of the students (73.6%;  $N = 270$ ) did not know the routes of exposure to PFAS. This percentage is significantly higher than in the population of adults from Slaskie province (56.4%;  $N = 237$ ) [13].

The risk perfluorinated aliphatic compounds pose to the human body arises from multiple routes of exposure: ingestion, inhalation, and dermal [1, 15–17].

The results of the present study show that the vast majority of students (80.6%;  $N = 296$ ) were not aware of the health risks posed by exposure to PFAS, while in the Slaskie study every third respondent could name a negative effect to the health caused by these compounds [13].

The number of studies on the negative effect of PFAS on the human body is insufficient. However, we have to remember that unambiguously proving that negative effect is a difficult and complex process [3, 18–19]. In the future, the number of scientific proofs will be larger, because the effects of long term exposure to perfluorinated compounds will be known. It is important to attempt to limit the exposure to PFAS within a society. Such actions will only be successful, if the people will be aware of the risks posed by PFAS and aware of the means to limit exposure.

Sadly, the awareness of students from Swietokrzyskie province on ways to limit exposure to PFAS is virtually non-existent, seeing as 81.7% (300) cannot name a single action that can be undertaken in that respect. A slightly higher awareness was shown by adults from Slaskie province, where 65.2% (274) of the respondents declared they did not know how to avoid excessive exposure to these dangerous compounds [13].

The results of the present study show the insufficient amount of awareness of the perfluorinated aliphatic compounds in the society. The present study,

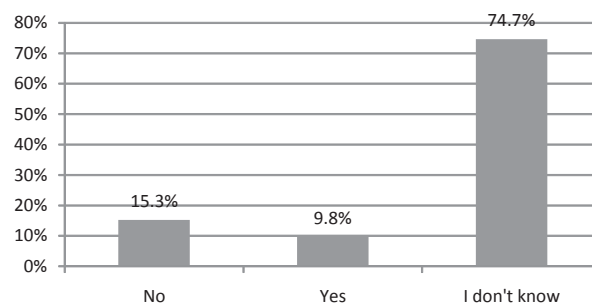
conducted in Swietokrzyskie province, showed virtually non-existent awareness young people have of perfluorinated aliphatic compounds. Therefore, it is necessary to disseminate information on sources of exposure, their use, mechanisms of the toxic effect, and the possible routes of exposure. Such actions can undoubtedly pertain to increasing awareness in this field. Therefore, it is crucial to include health risks posed by PFAS to educational programs on environmental health risk factors aimed at all social groups, and especially children and youth in school age. Children and youth are more open to learning proper pro-health behaviours, including those connected with environmental health risks. Childhood is a stage in human development when health-related habits and behaviours, which later affect a person's lifestyle, are formed. Anti-health behaviours, which are frequently exhibited by teenagers can increase the risk of disease and pre-mature death, therefore pro-health education should be introduced at the earliest age possible.

## CONCLUSIONS

1. The awareness of perfluorinated aliphatic compounds (PFAS) in the population of students from secondary schools in Swietokrzyskie province is very poor.

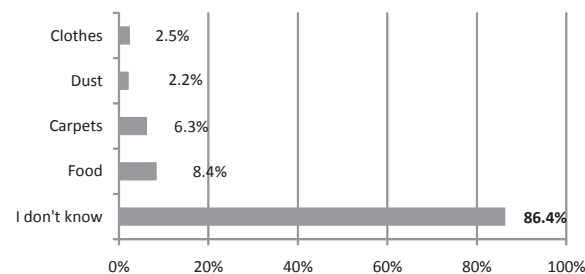
2. To limit the exposure to perfluorinated aliphatic compounds, it is necessary to increase public awareness, especially on sources and health risks posed by exposure to PFAS and on efficient methods limiting exposure.

3. Educational programs on health risks associated with PFAS aimed at all social groups, especially children and youths in school age, should be introduced.



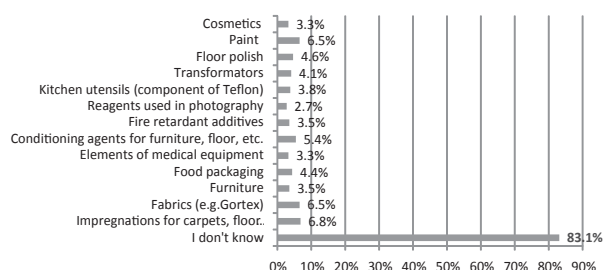
Source: Own study.

**Figure 1.** Have you ever been exposed to PFAS?



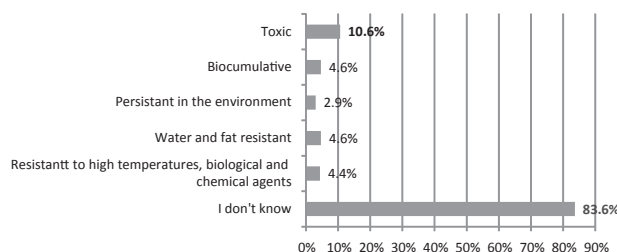
Source: Own study.

**Figure 2.** What PFAS sources do you know?



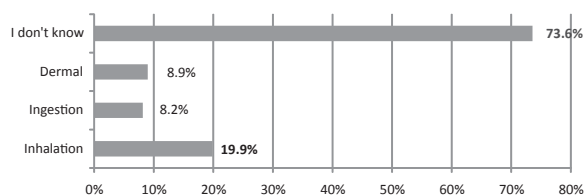
Source: Own study.

**Figure 3.** Where are PFAS used?



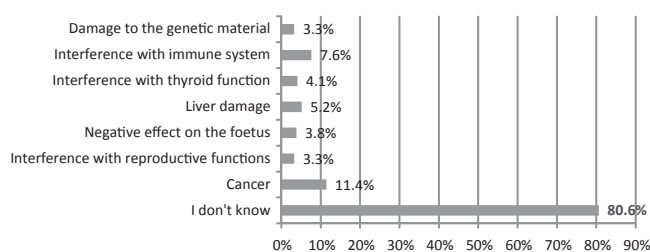
Source: Own study.

**Figure 4.** What characteristics of perfluorinated aliphatic compounds (PFAS) do you know?



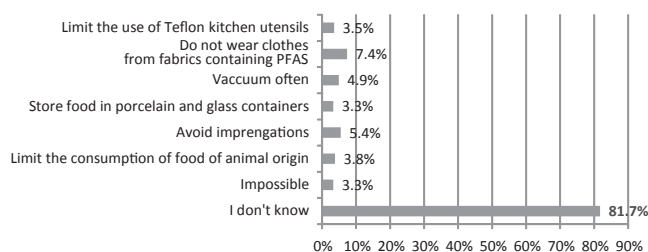
Source: Own study.

**Figure 5.** How do PFAS enter the body?



Source: Own study.

**Figure 6.** What are the health risks associated with exposure to perfluorinated aliphatic compounds?



Source: Own study.

**Figure 7.** How can you limit exposure to PFAS?

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Word count: 3278

• Tables: –

• Figures: 7

• References: 19

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**The sources of funding**

The review was funded by the authors.

**The conflict of interests**

The authors do not report any conflicts of interests.

**Cite this article as:** Tomczyk K, Dziubane G. Awareness of perfluorinated aliphatic compounds (PFAS) in the youth population of Swietokrzyskie province. PU-HSP 2016; 10, 2: 21–26.

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Received: 19.01.2016

Reviewed: 24.05.2016

Accepted: 26.06.2016