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THE REMOVAL OF ASBESTOS AND ASBESTOS-CONTAINING PRODUCTS AS THE COMPONENT OF WASTE MANAGEMENT

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Introduction

Asbestos is a set of naturally occurring minerals. They belong to the amphibole class and to the serpentine class. Chemically, they are hydrated iron-magnesium aluminosilicates that are frequently composed of $Ni^{2}+$, $Ca^{2}+$, Na+, $Mn^{4}+$. In nature their number is approx. 150 (Pyssa, 2014). For years asbestos has been used for construction purposes due to its insulation and fireproofing properties. Owing to its carcinogenic effect on the living organisms, asbestos was considered as the harmful raw material, the usage of which in housing began to be banned and the removal of asbestos from both man's existence and from the natural environment began to be necessary. These issues are regulated by legislative regulations on waste management on both the EU level and the national level.

Asbestos and asbestos-containing products

The occurrence

Asbestos is a mineral that can be found in the entire world. However, its greatest deposits being important for industrial purposes were located in two countries: Canada and the USSR – with 2/3 of the global production of this mineral at the turn of the 20th century. Among highly developed countries in the 20th century, for example, Italy and the United States of America produced approx. 2% of the global production of asbestos respectively, whereas Greece and Australia approx. 1% of the global production of asbestos. In Africa its main producers were the Republic of South Africa and Zimbabwe (10% of the global production of asbestos in the 20th century). The producers with an average level of production were China and Brasil (7% of the global production of asbestos in the 20th century). The data regarding the volume of production as regards the most important producers of asbestos in the years 1940-2013 is included in table 1.

In the first decade of this century asbestos is no longer excavated in both highly developed countries and in African countries. A similar level or even slightly more significant production of this mineral is recorded in Russia, China and Brasil which are presently the key producers of asbestos that is, on the other hand, banned in countries known as economic superpowers.

Table 1. Global potentates in the production of asbestos (1940-2013)

Producer	Production volume				
	1940	1960	1970	2000	2013
The Soviet Union (2013-Kazakhstan)	102 000	598 743	1 065 943	983 000	1 000 000
Canada	313 514	1 014 647	1 507 420	320 000	-
RSA	24 850	159 540	287 416	18 782	-
Zimbabwe	50 809	121 529	79 832	145 000	-
China	20 015	81 647	172 385	350 000	400 000
Brasil	500	3 538	16 329	170 000	300 000
USA	18 198	41 026	113 683	5 260	-
Globally – Total value	573 728	2 213 533	3 493 800	2 070 000	1 940 000

Source: own elaboration on the basis (Pyssa, 2014).

The origins of asbestos date back to the ancient times. At that time asbestos was used, among others, for making tablecloths, shrouds, handkerchiefs and also as oil lamp wicks. Between the 15th century and the 19th century asbestos was used mainly because of its fireproofing properties. It was used as the admixture for non-flammable paper and for the production of candle wicks and fire-resisting fabrics. The golden age of using asbestos in various industry sectors was at the turn of the 19th and 20th century. It was applied for producing gaskets made of asbestos and rubber in order to use them in steam engines, fire-resisting fabrics used by firefighters, building materials (asbestos and cement slabs – eternite – which is a perfect construction material for roofing tiles and cladding as well as panels for decorating walls and ceilings), (Pyssa, 2014).

Properties

The manner of using asbestos for commercial activities is dependent on its type. Table 2 presents both physical and chemical properties of the main types of asbestos minerals.

Table 2. Physical and chemical properties of the most popular asbestos minerals

Mineral / Properties	Chryzotile	Crocodolite (riebeckite)	Grunerite (amosite)	Anthophyllite	Tremolite	Actinolite
Chemical formula	$Mg_3(Si_20_5)(0H)$	$Na_2FeII_3FeIII_2(Si_80_{22})(0H)_2$	$(Fe,Mg)_7(Si_80_{22})(OH)_2$	$(Mg,Fe)_7(Si_80_{22})(OH)_2$	$Ca_2Mg_5(Si_80_{22})(0H)_2$	$Ca_2(Mg,Fe)_5(Si_80_{22})(0H)_2$
Chemical analysis (% of the main components)						
$Si0_2$	38-42	49-56	49-52	53-60	55-60	51-56
Al_20_3	0-2	0-1	0-1	0-3	0-3	0-3
Fe_20_3	0-5	13-18	0-5	0-5	0-5	0-5
FeO	0-3	3-21	35-40	3-20	0-5	5-15
MgO	38-42	0-13	5-7	17-31	20-25	12-20
CaO	0-2	0-2	0-2	0-3	10-15	10-13
Na_20	0.1	4-8	0-1	0-1	0-2	0-2
Na_20+	11,5-13.0	1,7-2.8	1,8-2,4	1.5-3.0	1,5-2,5	1.8-2.3
Colour	From white to pale green	Blue	From light grey to pale brown	From white to grey, pale brown	From white to grey	From pale green to dark green
Decompo-sition temperature (CC)	450-700	400-600	600-800	600-850	950-1040	620-960
Acid resistance	With the ten-dency of fast reaction	Good	With the ten-dency of slow reaction	Very good	Very good	With the tendency of slow reaction
Alkali resistance	Very good	Good	Good	Very good	Good	Good
Fiber construc-tion (texture)	Mostly flexible, silky and hard	From flexible to breakable	Mostly breakable	Mostly breakable	Mostly breakable	
Main producers – countries	Canada, China, USA, Italy, Zimbabwe, South Africa, Russia	South Africa	South Africa	Mozambique, USA	Italy, USA	

Source: (Smolik, Gembalczyk, 2007).

The asbestos volume necessary to be removed in Poland

The problem of asbestos occurs also in Poland. The character as well as the severity of the asbestos problem in Poland is the function of the volume of the material used so far in Poland's economy. It is estimated that in the years 1945-1998 (when, owing to the initiated implementation of the gov-

ernment program of removing asbestos in Poland, its usage is banned) approximately 2 mln tones of this mineral have been used. It was mainly t chryzotile asbestos imported from the USSR. The main material used for the production of asbestos and cement products (a-c) that were mainly used in the construction sector was chrysotile asbestos, whereas till the mid 1980s crocodolite (the most aggressive asbestos) was used for the production of mostly pressure pipes (Szałucha, www.zielonewydarzenia.pl).

The most serious situation as regards the removal of asbestos is in two districts: Mazowieckie and Lubelskie, whereas a slightly less serious situation is observed in the districts located in the Western part of Poland: in Wielkopolskie district and Kujawsko-Pomorskie district. Podlaskie district is among districts with a medium advancement degree of the asbestos problem. In this dimension the problem is of material type and determines the scale of tasks that need to be realized so that the problem can be fully solved. Thus, also the hazards of epidemiological and ecological character will be eliminated.

Epidemiological and ecological hazards posed by asbestos and asbestos-containing products

From the epidemiological perspective the main problem which first of all gives reason to taking actions aiming at complete removal of asbestos and asbestos-containing products from Poland is the fact that this mineral has proven carcinogenic effect on man and is considered as one of the most frequent carcinogenic factors in the environment. It is stated in literature that "pathogenic activity of asbestos is the result of inhaling the fibers suspended in the air. The risk resulting from absorbing the asbestos fibers via the alimentary canal is marginal for health. The aggressive character of asbestos fibers is related to the degree of penetration and to the amount of fibers in the lower tract of the respiratory system. This process is dependent on both the physical and aerodynamic properties of the fibers. Thin fibers with the diameter smaller than 3 μm are more easily both transmitted and deposited in the lower tracts of the respiratory system. Adversely, thick fibers with the diameter larger than 5 μm are stopped in the upper part of the respiratory system. Twisted fibers of chrysotile with a large diameter have the tendency to stop mostly in the upper parts in opposition to needle shaped fibers of amphibole asbestos which easily penetrate the lung areas. For human organisms the greatest threat to a human organism is posed by respirable fibers with the diameter smaller than 3 μm, i.e. the fibers that get into the pulmonary alveolus where they can penetrate the lung tissues" (Smolik, Gembalczyk, 2007). Therefore, the most serious hazard for the respiratory system is

posed by asbestos fibers that penetrate it without pain but cause irreversible damage depending on the depth of the penetration.

There are distinguished three types of the exposure to asbestos dusts, the main factor of epidemiological hazards. These are:

- occupational exposure – related to working in a mine or in plants producing and using asbestos products as well as related to working in car garages and removing asbestos products and materials containing asbestos;
- para-occupational exposure – regards inhabitants of the areas located near mines and plants processing asbestos as well as the families of workers in these plants;
- environmental exposure – related to the presence of asbestos in the atmospheric air, drinkable water and groceries.

Although everyone is exposed to asbestos dusts, the largest hazard is posed to the workers of companies that use asbestos in their technological processes. Asbestos is responsible for a considerable number of occupational diseases. According to the International Labour Organization systematic contact with asbestos dusts exposes people to the risk of suffering from one of the following diseases (*Zapobieganie zagrożeniom*..., 2007):

- asbestosis – slow scarring of the lung tissue which results in respiratory failure;
- lung cancer occurring usually 10-40 years after the first exposure, its development is accelerated by asbestosis and nicotine addiction;
- mesothelioma, cancer typical for asbestos exposure, caused by microscopic respirable asbestos fibers deposited in lungs, it develops 10-40 years after the first exposure.

The data obtained from the Nofer Institute of Occupational Medicine in Łódź implies that the number of occupational diseases caused by asbestos dusts has been increasing recently. In 2005, for example, the number of recorded cases of mesothelioma disease increased almost five times (4,75) when compared with the year 1995. Taking into consideration the statistics of other countries as regards the number of disease cases also in Poland the number of disease cases is likely to increase, especially as regards lung cancer and mesothelioma (*Zapobieganie zagrożeniom*..., 2007). This is a postponed effect of the previous exposure. Therefore, one may expect that despite progress in the program of asbestos removal, the epidemiological problems related to the contact of human populations with asbestos will be more intensive in the future. Hence it will still constitute serious challenge for medical services and state budget which are burdened by the costs of treating people for the diseases caused by asbestos dusts.

The seriousness of the epidemiological problem is intensified by the fact that owing to the common usage of asbestos in economy in the past, the major group of Polish population could have contact with this substance. Therefore, the problem needs to be solved promptly which, owing to its scale, constitutes serious challenge of organizational and economic character.

The solution of the asbestos problem as the priority of the state healthcare policy and ecological policy and one of the basic aspects of waste management

The occurrence of the aforementioned hazards induced contemporary countries to undertake the activities aiming at complete removal of asbestos and asbestos-containing products. In Poland such activities were initiated at the end of the 20th century but they were paid attention to much earlier. On 19 June 1997 Seym passed the resolution on the program of asbestos removal from economy (M. P. from 1997, No. 38 item 373). On the same day there was enacted a bill introducing a ban on using asbestos-containing products (Journal of the Acts of 1997 No. 101, item 628 with further modifications) and the Cabinet approved of the *Program of removal of asbestos and asbestos-containing products from Poland* (Warsaw, May 2002). It is estimated that in Poland there were then approx. 15,5 mln tonnes of asbestos-containing products (85% in the construction sector). This quantity was estimated on the basis of the statistical data regarding production, import and distribution of asbestos products and on the basis of the approved indicators showing the usage of them (Szałucha, www.zielonewydarzenia.pl).

When the production and usage of asbestos products have been discontinued the main sources of hazards are:

- improperly stored asbestos waste, including abandoned rubbish dumps, especially in forests and uncovered excavations;
- usage of asbestos products, which results in air pollution with asbestos dust as the result of: corrosion and mechanical damages of asbestos and cement tiles, abrasion of clutch and brake discs,
- improper removal of asbestos-containing products from roofing and elevation.

Therefore, the exposure to asbestos is the result of abnormalities in the realization of the asbestos removal program, i.e. non-observance of the designed procedures of removing asbestos products from buildings and installations, their transport to the storage spot and storage. However, it needs to be remembered that so far there remain significant amounts of

asbestos in buildings used by people and asbestos dusts still have harmful effect on their health.

In this context it is necessary to mention that asbestos dusts have negative effect also on the natural environment. Asbestos dusts deposited there constitute additional source of epidemiological hazards.

Presently the following anti-asbestos program is in force: *Program of Asbestos Abatement for the years 2009-2032 passed by the Parliament on 14 July 2009, altered by the act of the Cabinet of 15 March 2010* (Warsaw 2010). The main objectives specified in the previous program have been maintained there, these were:

- removal of asbestos-containing products from Poland;
- reduction of negative effects for health that were caused by the presence of asbestos in the country;
- elimination of the harmful effect of asbestos on the environment.

The necessity to approve of a new anti-asbestos program was the result of Poland's accession to the UE, which changed the legislative, economic and social conditions of implementing the program. The *Program's* tasks are distributed on the central level (creation of legislative, political and economic conditions), regional level (implementation of objectives and tasks of the *Program* on the regional level) and local level (municipal, operationalization of objectives and tasks on the directly executive level. Owing to the perspective of perceiving the asbestos problem there ought to be mentioned tasks that are imposed by the Program especially on municipalities:

- collection (by a village mayor or a city mayor) of information regarding the quantity, type and location of asbestos-containing products and passing of this information to the district marshal by the Asbestos Database;
- preparation and updating of the programs related to the removal of asbestos and asbestos-containing products as well as taking them into consideration in the municipal waste management plans;
- organization of local trainings as regards the asbestos-related problems;
- organization of the removal of asbestos and asbestos-containing products from the obtained Polish and EU funds while taking into consideration the principles stipulated in the *Program*;
- inspiration for citizens to adopt proper attitude towards the asbestos problem;
- cooperation with a marshal of the provincial parliament as regards the inventory of asbestos-containing products and programs for their removal as well as with regard to proving appropriate technical and transport background for them;
- cooperation with mass media in order to voice the *Program* objectives and tasks as well as the responsibility of citizens for its realization;

- cooperation with non-governmental organizations supporting the *Program*.

An essential turning point in the Program realization was the day 22 January 2010 when the act on waste and some other acts were passed (Journal of Acts of 2010 No. 28, item 145). The act facilitated the processing of waste containing asbestos in devices and by doing so separate requirements for these types of devices were introduced. The Act on waste passed on 14 December 2012 (Journal of Acts of 2013 r., item. 21) confirmed that asbestos is a hazardous material, which involved all the consequences for the ways and procedures of tackling with it.

From the economic perspective financing of the Program tasks has crucial importance. These are the sources of financing the removal of asbestos:

- own resources of the buildings' owners;
- own resources of private investors;
- own resources of local self-government units;
- resources of the state budget which are at the disposal of the Ministry of Economy;
- resources of environmental protection funds.

The National Fund for Environmental Protection and Water Management over the last two years has initiated two support programs related to the removal of asbestos:

- The Priority Program for the years 2010-2013, within the frameworks of which funds were allocated for particular regional funds for environmental protection and water management. The total sum of planned payments is 38 mln PLN (in 2011 – 6 mln PLN, 2012 – 10 mln PLN and in 2013 – 22 mln PLN).
- The Priority Program SYSTEM – support of activities related to environmental protection and water management realized by WFOŚiGW (Regional funds for environmental protection and water management) for the years 2014-2018. Allocation of funds is anticipated in 2015, whereas spending of funds – till 2017.

The Program for the years 2010-2013 has been evaluated five years after its realization. The evaluation resulted in making the following settlements:

1. The Ministry of Economy realizes the Program activities in the form of five subject-related sets. These include: legislation tasks, educational-informational tasks, tasks related to the removal of asbestos-containing products, monitoring of POKA realization as well as tasks related to health protection.

2. In the years 2009-2014 there were realized 71 educational and informational projects aiming at intensifying the initiative of self-governments. All in all, within the frameworks of the funds earmarked for this purpose there were spent 4,13 mln PLN. Within the frameworks of the activities there were organized numerous local trainings for volunteer fire brigades, municipal office, cooperative societies and housing associations. In sum, in the years 2010-2011 and 2013-2014 there were trained 857 people. What is more, the three-year training session for self-government administration was participated by 2 934 people.
3. Within the frameworks of the realized tasks till the end of 2013 1,57 mln Mg of asbestos waste was neutralized. Successful acceleration of the rate at which harmful products are removed is conditioned, among others, by the elaboration of municipal programs of removing asbestos and the collection of reliable information on the amount and location of these products.
4. In the years 2009-2014 the Ministry of Economy offered financial support for realization of these activities to 967 units of territorial self-government. As the consequence, 84% of municipalities in Poland introduced data from its area in the Asbestos Base.
5. In 2013 there was elaborated up-to-date Electronic System for Spatial Information (ESIP) for monitoring the realization of the Program of Asbestos Abatement from Poland. The so called ESIP integrates the information from the Asbestos Database with the spatial data. The system enables the collection of a set of data on selected levels of accuracy, unbiased and complex verification of the cataloguing of asbestos products, rationalizes the process of making decisions and enhances the effectiveness of management as regards the process of POKA realization.
6. In municipalities with the largest asbestos contamination, i.e. in Szczucin and Ogrodzieniec, the removal of asbestos products from usage was a success. Moreover, all the plants that previously produced asbestos products were cleaned and organized and most of these plants run an entirely different economic activity. There was observed also a moderate level of air pollution with asbestos fibers in Poland.
7. The European Union approved of Poland's activities. The European Parliament resolution from 2013 included the appeal to member states to follow Poland and assess the effect and analyze costs with reference to the plan of acting for safe removal of asbestos till 2028.

Despite the achievements gained until now there is still an urgent need to systematically monitor the asbestos problem and the progress in solving this problem especially in areas that are weaker in both social and economic terms, i.e. in rural areas where the social factor is least efficient and lack of

investment for these areas is a well known fact. From the economic perspective when particularly essential legislative conditionings are analyzed on a large scale, the asbestos problem in rural areas in Podlaskie district is particularly essential.

Supreme Audit Office conducted the evaluation in 2015 (April-September). The audit regarded the years 2009-2015. The results are decidedly negative; it was stated unanimously that the deadline for removing asbestos-containing products will not be met. There was a problem with finding satisfactory financial means for the secure removal of asbestos-containing products. There was also no success as regards the elaboration of legislative bases ensuring effective cooperation between the owners of buildings containing asbestos and self-government authorities. However, what matters most is the fact that the amount of asbestos that needs to be removed is still not known (Realization of the ''Program of Asbestos Abatement..., 2017). The amount of asbestos mentioned in the Asbestos Database is not reliable because 26% of municipalities (data from October 2015) did not introduce data into the regional database on asbestos products and waste containing asbestos. The Electronic System for Spatial Information, the main instrument for monitoring, has not been implemented so far.

The removal of asbestos and asbestos-containing asbestos takes place in accordance with a certain legal order. In Poland in the legislation regarding the solution of this problem the lawmaker proved to be inconsistent. The Program was established via the Act of Government, thus it is not the act of the universally binding law. The obligation to remove asbestos and asbestos-containing products that territorial self-government units have been imposed on results from the regulations of the domestic law, not from the statutory regulation. Adversely, the regulations for the units using asbestos and asbestos products were regulated by the legislative act in the form of a decree. Lack of legislative regulations for municipalities resulted in the inadequate attitude to solution of the asbestos problem which was frequently noticeable when the activities listed in the *Program* were not undertaken.

Until now more than 43% (23 mln PLN) of the funds earmarked for the entire period of the Program realization have been spent. The Minister of Economy is responsible for the distribution of funds. The activities undertaken by the Ministry and by the Program coordinator do not result in the proper realization of the planned undertakings. The amount of the asbestos products, the amount of harmful waste and asbestos-containing products as well as the number of municipalities using WBDA have not been identified so far. It was impossible to calculate what is the number of people working with asbestos as well as the number of workers trained to work with asbestos (Realization of the ''Program of Asbestos Abatement..., 2017).

Following the evaluation activities the Supreme Audit Office determined which activities ought to be taken by the Ministry of Economic Development. These include:

- overview and analysis of the valid regulations related to asbestos in order to elaborate a consistent, compatible and all-embracing proposal of changes;
- financial and logistic support in the removal of asbestos-containing products from public buildings with the first degree of urgency and in the areas with the largest concentration of asbestos in the environment;
- elaboration of financial support instruments for the exchange of roof and elevation coating;
- search for secure methods of neutralizing asbestos ([Realization of the ''Program of Asbestos Abatement…, 2017).

The Supreme Audit Office admitted that the realization of the objectives set up in the *Program* till 2032 is impossible and addressed the Prime Minister to consider the rationalization of the *Program*.

Conclusion

Management of hazardous waste, including asbestos and asbestos-containing products, is of particular importance from both epidemiological and ecological perspective because of the hazards it causes. They have been identified and in 2012 there was introduced a ban of importing, processing and selling asbestos in 53 countries. In Poland, in accordance with the passed long-term Program of removing asbestos and asbestos-containing products used in Poland and transformed into the Program of cleaning the Country for the years 2009-2032, till 2032 at the latest asbestos and asbestos-containing products will have been removed. The evaluation of these Programs prepared by the Supreme Audit Office indicated inadequate realization of the Program. There were shown specific objections and recommendations. Their realization may prompt NIK (Supreme Audit Office) to exclaim that the works on the removal of asbestos and asbestos-containing products will be completed earlier than 200 years ahead from now. The realization of "The Program of Asbestos Abatement in Poland for the years 2009-2032" implies that *In accordance with the estimates of the Supreme Audit Office when the present rate at which asbestos-containing products are removed is maintained, these works may end within approx. 200 years,* [Realization of the ''Program of Asbestos Abatement…, 2017, p. 9).

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