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RECYCLING OF ASBESTOS-CEMENT WASTE – AN OPPORTUNITY OR A THREAT?

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Abstract: Asbestos-cement waste from roof coverings and facades are classified as hazardous materials and should be successively removed from buildings. The current management of these wastes is limited to their controlled depositing in landfills, which does not ultimately solve the problem of their impact on the environment in the future. The article presents the current state of disposal of asbestos in Poland, with particular emphasis on the Silesian Voivodeship. The literature reports on the methods of neutralizing this type of waste and the possibility of their recycling were analyzed. It was found that the most popular way of recycling asbestos waste is thermal treatment, and the least effective - chemical treatment. Unfortunately, legal barriers prevent the spread of these solutions in the country in practice, despite the fact that safe methods of recycling asbestos-cement products are known.
Keywords: asbestos-cement sheets, hazardous waste, recycling, environmental protection, concrete

1. THE "ASBESTOS" SITUATION IN THE COUNTRY AND IN THE WORLD

Asbestos-cement materials were widely used in the construction industry, but due to the presence of harmful respirable asbestos fibers, many countries banned their production and use as early as the 1980s (Iceland - 1983, Norway - 1984, Denmark - 1986 and Sweden - 1986). According to (Frank, 2020). Currently, the use of these products has been banned in over 60 countries. Unfortunately, there are countries where its production has not been discontinued. These include Russia, Kazakhstan and China. According to the data of the United States Geological Survey (USGS), in 2019 the production of asbestos fibers per mass was approximately 1 090 000 Mg (Fig. 1). At that time, Russia, Brazil and China had the largest share in the world production of asbestos products. The last American producer of asbestos, according to (Asbestos Data Sheet - Mineral Commodity Summaries 2020, 2020), ended its operations in 2002, but these minerals are still imported and used in this country. It was estimated that in 2019 domestic consumption of asbestos in this country was

100 Mg. In Zimbabwe, the last asbestos production took place in 2013, while the only Brazilian asbestos producer has suspended its mining operations.

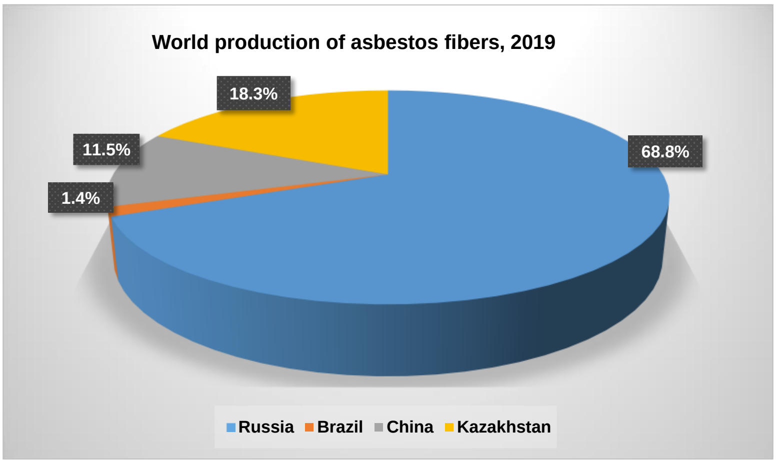


Fig. 1. Percentage share of countries in the production of asbestos fibers in 2019 (based on International Ban Asbestos Secretariat, 2019)

It should be emphasized that the use of asbestos in an appropriate manner does not pose a threat, however, any mechanical damage and incorrect management of the resulting waste are very dangerous. Therefore, in 2002, Poland was the only country in the European Union to introduce the "Asbestos Removal Program for 2009-2032". This program defines activities related to the removal and neutralization of asbestos products and the minimization of their negative effects on the environment. These tasks, by definition, are to be carried out on three levels: central, voivodeship and poviat or commune. Based on figures (Asbestos Base, 2021), the amount of asbestos-cement waste inventoried in Poland is currently over 8 429 626 Mg. However, this is not the total mass of all existing waste, due to many unidentified places of disposal. At present, only 1 347 098 Mg of asbestos cement has been neutralized, which is only 16% of inventoried waste. The current situation of utilization of this waste at the voivodeship level is shown in Figure 2. As it can be seen from the presented data, the asbestos disposal process is very slow and impossible to complete within the assumed timeframe. It is worrying that in all voivodships still over 60% of inventoried waste has not been neutralized. The greatest amount of waste was neutralized in the Lubuskie Voivodeship (40%) and the least in the Łódzkie Voivodeship (10%).

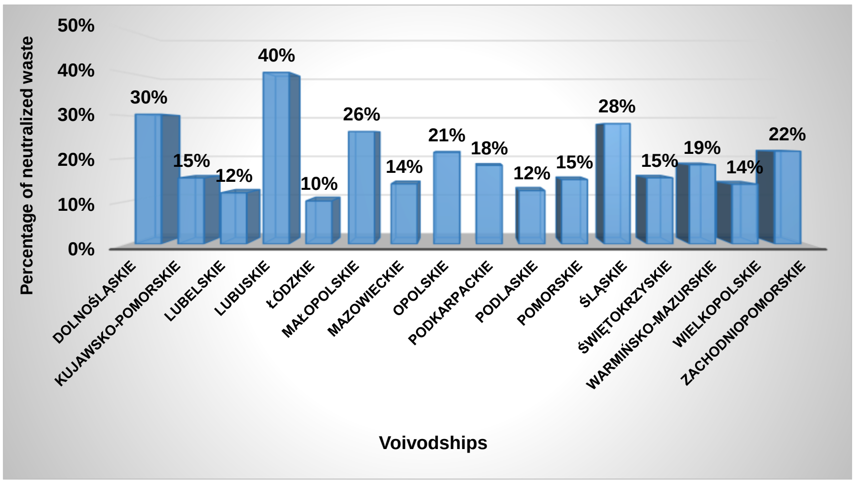
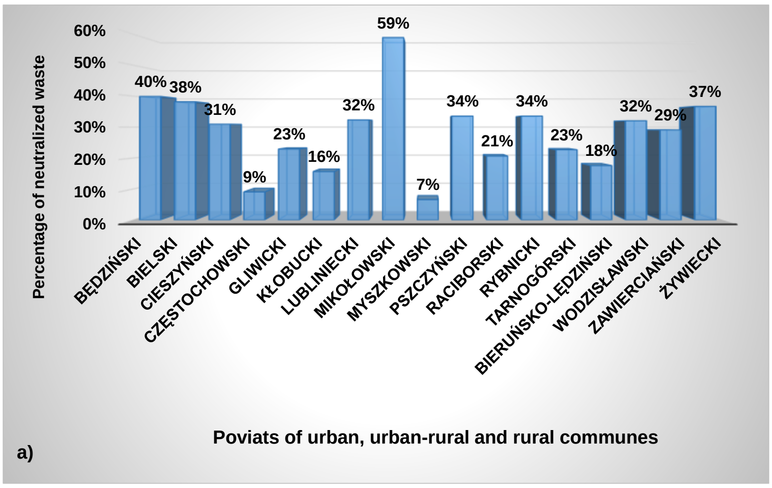


Fig. 2. Percentage share of neutralized asbestos waste at the voivodeship level in 2021 (Asbestos Base, 2021)

Figure 3 shows data on disposed of waste in poviats of urban and rural communes (Fig. 3a) and in cities with poviat status (Fig. 3b) of the Silesian Voivodeship. The data shows that only in two poviats, including urban-rural areas, the level of recycled waste was 40% or more. The lowest level of recycling in this voivodship was recorded for the Myszków poviat (7%). The situation is slightly better in the areas of cities with poviat status, where this indicator exceeds 40% within 6 cities. Unfortunately, the level below 20% was also recorded for 6 cities. The reason for this phenomenon is the lack of sufficient financial resources to cover all costs related to the removal and replacement of the roofing and the low social awareness of the inhabitants, especially in smaller towns. Of course, it is possible to take advantage of the co-financing, but it only covers the costs of dismantling and depositing waste (Łuniewski and Łuniewski, 2019; Ulewicz and Liszewski, 2020).



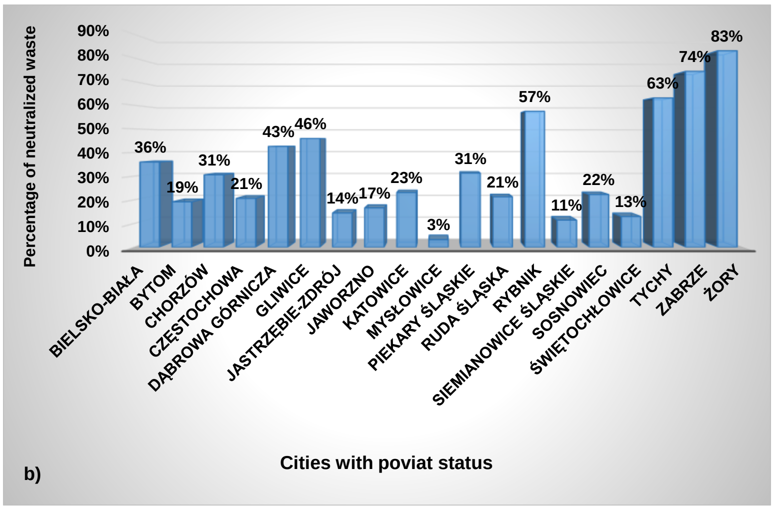


Fig. 3. Percentage share of neutralized asbestos waste at the poviat level of the Silesian Voivodeship in 2021 (Asbestos Base, 2021)

Therefore, many residents disassemble themselves without the use of appropriate protective measures, and store the dismantled waste on their property, transport it to the forests, creating the so-called wild dumps or buried in the ground. According to the regulations in force in Poland, the only permitted method of disposal of asbestos roofing is their dismantling by specialized companies and then securing them with polyethylene foil with a minimum thickness of 0.2 mm and storing them in a properly secured place. It is currently the only method of managing this type of waste in the country in line with Polish law. Unfortunately, it is not very profitable and not ecological in the long run. That is why some countries implement innovative technologies for the neutralization and reuse of this waste.

2. METHODS OF RECYCLING OF ASBESTOS-CEMENT WASTE

The presence of respirable fibers (diameter less than 3 μm and length> 5 μm) in asbestos waste, harmful to human health, currently prevents their use in this form. Therefore, it is necessary to detoxify (cleansing of toxins), which consists in destroying the fibrous structure of the waste. Thermal treatment is one of the best known and most effective methods. This process involves the neutralization of asbestos at temperatures above 700° C. The obtained end product can be successfully used in the construction sector for the production of ceramics, cement and geopolymers. According to (Wójcik, 2018), vitrification is a frequently used method in highly developed countries. It consists in destroying asbestos fibers at a temperature of up to 1600° C. The obtained product is a high hardness amorphous substance that can be used as a substitute for quartz or basalt. In the literature, there are reports of vitrification tests of asbestos-cement waste and CRT glass cullet at a temperature of up to 1400° C. At this temperature, the vitrification of asbestos products is highly effective and makes it possible to simultaneously utilize other waste difficult to manage (Iwaszko et al., 2021). Unfortunately, the disadvantage of this solution is the high costs associated with providing the necessary energy. An interesting solution is the combination of mechanical and thermal processing technologies, i.e. the MTT (Microwave Thermal Treatment) technology. It was patented in Poland, but was never implemented in practice. The use of microwave technology to decompose asbestos in waste has been described in many publications (Leonelli et al., 2006; Yoshikawa et al., 2015). This process is competitive compared to traditional thermal technology due to the reduction of time and energy needed to perform the treatment. This technology allows for the reduction of the processing temperature with the use of fluxes, however, according to (Obmiński, 2021), it may result in incomplete destruction of the asbestos. Therefore, the MTT technique should be used to reduce the harmfulness of asbestos waste, not to recycle it. Another test solution in the laboratory for the disposal of asbestos waste is mechanical treatment with the use of high-energy mills (Iwaszko et al., 2017) and chemical treatment (the use of strong bases and acids in this process creates a potential environmental hazard and limits the recovery of some substances, e.g. magnesium). However, these methods are not used in practice. The treatment with the use of electric voltage, proposed by Canadian scientists, is also one of the more unconventional technologies. As a result of the ionization process, asbestos fibers are destroyed (Martin et al., 2017). In the United States, where the use of asbestos products has not been banned, coating asbestos products with special means without removing them in buildings has gained great popularity (Pawełczyk et al., 2017).

3. ASBESTOS-CEMENT WASTE AS A SECONDARY RAW MATERIAL

In recent years, the literature contains a number of reports on the use of various wastes, including those difficult to manage, for the production of cement mortars and concretes commonly used in construction. For this purpose, waste was used such as ceramics (Ulewicz and Halbiniak, 2016; Kumar et al., 2021), glass (Pietrzak and Ulewicz, 2017; Dong et al., 2021), polymer materials (Pietrzak and Ulewicz, 2018; Pietrzak, 2018; Ulewicz and Pietrzak, 2021) fly ash from biomass combustion (Jura, 2020; Popławski, 2020; Jura and Ulewicz, 2021), ash from sewage sludge incineration (Pietrzak, 2019) or copper industry waste (Helbrych, 2019). Attempts were also made to use asbestos waste in the production of building materials. The research carried out by (Viani and Gualtieri, 2014) showed that the product obtained as a result of thermal treatment of asbestos waste can be used for the production of magnesium phosphate cement (MPC). This saves both energy and natural resources. Italian scientists have proved that the secondary raw material produced in the thermal inertization process can be used in the production of concrete and reinforced concrete elements, as a partial replacement for cement (Gualtieri and Boccaletti, 2011; Ranaivomanana and Leklou, 2021) and in the production of geopolymers (Gualtieri et al., 2012; Gualtieri, 2013). These activities have a positive impact on the natural environment due to the reduction of CO_2 emissions released during the production process. Detoxified eternite waste was also used for the production of ceramic materials (Kusiorowski et al., 2014; Kusiorowski et al. 2015). The addition of waste, as shown by the authors, only slightly reduces the compressive strength and durability (frost resistance) of the produced clinker ceramics in relation to the reference materials, while maintaining the parameters in accordance with the applicable national standards. Also, a small addition (5%) of asbestos-cement to the production of building bricks does not adversely affect its compressive strength parameters, but causes discoloration on the surface, which reduces the aesthetics of the product

(Kusiorowski et al., 2014). Asbestos waste can be used to produce glass ceramics (Gualtieri and Tartaglia, 2000). The authors of the publication estimated that the costs of such a process are 10 times lower than the costs of traditional disposal of toxic waste. In addition, the resulting product is completely safe for the environment and shows high point resistance due to the reduction of water absorption and an increase in apparent density. An innovative way of using asbestos waste in combination with fly ash is the production of ceramic foams (Hui et al., 2021). The highest permeability was obtained for samples based on cordierite, containing 17.5% aluminum oxide. The proposed technology for the production of ceramic foams, which can be used for the filtration of high-temperature exhaust gases and special wastewater, will reduce production costs and the consumption of energy and natural resources.

4. CONCLUSIONS

In Poland, the only legally binding method of asbestos waste disposal is its disposal by depositing in landfills, which is not ecologically justified. Currently, the level of disposal of this hazardous waste is low. The highest utilization rate was recorded in the Lubuskie Voivodeship (40%) and the lowest in the Łódzkie Voivodeship (10%). Taking into account that safe technologies of recycling asbestos-cement products are known in the world, it is worth considering the implementation of modern methods of processing this waste in the economy system in Poland and the introduction of appropriate legal regulations in this area. The subject of asbestos-cement waste recycling is still relevant, as evidenced by numerous publications in this field reporting on new solutions and attempts to use hazardous asbestos waste in the production of various materials, including building materials. This method seems to be more ecological than depositing them in landfills, where they do not pose a threat only temporarily (after damaging the protective foil, they will pose a threat again).

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