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Asbestos Utilization Costs on the Example of Functioning Landfill of Hazardous Waste

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Abstract. Asbestos is a trademark of mineral fibres, which are the natural minerals found in nature. Products containing asbestos fibres, in accordance with the national and EU legislation, are covered by the production prohibition and forced to be removed. In Poland, the asbestos removal process started with the adaptation of the EU law by the Council of Ministers Treatment Program of the National Asbestos for the years 2009-2032. The purpose of the dissertation was to analyse the costs associated with the disposal of the costs of collection, transport and disposal of waste. Methodology consisted in obtaining information on the raw materials needed to produce asbestos sheets. The analysis allowed us to determine the asbestos removal cost and include state subsidies in the calculations.

1. Introduction
Asbestos is included in the list of hazardous substances [1, 2] under the index number 650-013-00-6 as a substance with documented carcinogenicity category 1, what makes it one of the most dangerous minerals on earth. According to experts from the Institute of Occupational Medicine, asbestos products do not pose a threat to the people or the environment when they are in good condition, in one piece, undamaged and not corroded. Asbestos becomes a health hazard only by dismantling [3], corrosion or any damage to asbestos-containing products (breaking, crushing, cutting). After these processes, there is a high possibility for the asbestos fibres to migrate into the air. Once inhaled to the lungs, they pose a risk of serious respiratory illness [4, 5]. This happens most often in the process of inconsistent asbestos removal [6].

In Poland, there are about 14 500 thousand tons of products containing asbestos [4], most often used for the production of:
- roof coverings;
- façade;
- balcony boards;
- ventilation and chimney ducts;
- household appliances: irons, cooking plates;
- pipes for water;
- sewage systems.

The import, manufacturing and using of asbestos-containing products in Poland has been prohibited since September 1998 due to the threat posed to human health and to the environment.
The plan, adopted by the Resolution of the Parliament from 14 July 2009 in the *Asbestos Removal Program in Poland for Years 2009-2032* [7, 8], defined main tasks necessary for removing and disposing of asbestos in the territory of Poland.

Poland is the only country in Europe that adopted an action plan for an asbestos-free country. This plan was created to show the essence of the removal of asbestos more than other waste, due its mischievousness for human health and life.

The main problems are: the slow pace of asbestos removal, huge lacks in quantity data and small number of landfills.

Figure 1 shows asbestos, which still needs to be neutralised in Poland on the basis data from the Asbestos Base prepared for local authorities. However, it should be noted, that by October 30, 2015, only 53 000 tonnes were added to the base, and it is less than 37% asbestos in Poland. So far, there is no reliable knowledge of the location and technical condition of the asbestos-containing products. According to these partial data, the majority of asbestos that needs to be disposed of, is located in the Mazowieckie, Lubelskie and Lodz voivodships [9, 10].

![Figure 1. Asbestos that needs to be neutralized in Poland in thousands of tons. Own study based on data from the Asbestos Base](image)

The Ministry of Economy allocated in 2009-2014 14,3 million zł to co-finance the local programs for asbestos utilization. However, these expenses did not produce the expected results. No indicators of asbestos removal rates have been reached in the program.

Only less than 7% of asbestos-containing products have been removed since the program came into force, with over 43% appropriations for the entire programming period. With this pace, total removal of asbestos from the country would take around 200 years. It is worth pointing out that in these calculations only the amount of waste introduced into the Asbestos Base was included, which is incomplete and does not cover all products including that substance.

According to the Ministry of Economy calculations, 1 570 tonnes of asbestos waste were neutralized by the end of 2013. Approximately 100 - 150 tonnes of asbestos waste are deposited on
landfills each year. To achieve the main objective, literally, to eliminate those products by the end of 2032, the amount of removed and disposed asbestos should be increased to about 700 thousand tonnes per year.

It is important to speed up this process by developing municipal asbestos removal programs and gathering reliable information on the quantity and location of asbestos-containing products.

2. Materials and methods
The basis for financial analysis is the local municipality in Lesser Poland Voivodeship. The municipality is inhabited by 25,107 people including 12,509 women and 12,598 men, while its area is 153.01 km². Villages located in the municipality are of various sizes, the largest one has over 3000 inhabitants and the smallest is inhabited by 200 people.

Conducted analysis allowed to determine the costs of neutralization for asbestos products and their overall value.

The basic conversion unit in the whole study is a 24-tonne truck.

In order to achieve the purpose of the work, it was necessary to obtain the relevant data, such as the cost of materials for asbestos-containing materials, packaging and energy costs, transport costs, and the costs of disposing of 1 tonne of asbestos.

On the basis of the available information, the financial analysis of the process was carried out in order to know the full life cycle cost of the asbestos product in the form of asbestos plates. Information received from the Company was analysed under economic conditions to determine the key factors influencing the financial result.

The following costs, revenues and subsidies were collected:
- waste disposal costs;
- waste transport costs;
- subsidies from the state budget.

3. Results and discussions
Table 1 provides data on the quantities of raw materials and other materials that make up discs that are one of the most common kind of asbestos in Poland. As it was mentioned earlier, the conversion unit is one 24-ton material truck. The calculations include the mass of the raw materials, minerals needed and the price. The weight of all plates is almost 17.5 tonnes, which is the optimal load for the volume of plates as regards the dimensions of the vehicle. The cost of all components oscillates around the amount of 13.9 thousand of zł.

| Constituent material          | Mass (t) | Price (thousands zł) |
|------------------------------|----------|----------------------|
| Cement (Portland)            | 15.291   | 6.01                 |
| Amorphous silica             | 1.008    | 1.26                 |
| Cellulose                    | 0.480    | 0.91                 |
| PVA fibre                    | 0.384    | 5.30                 |
| Calcium carbonate            | 0.198    | 0.011                |
| Fly ash                      | 0.048    | 0.006                |
| Safety tape                  | 0.036    | 0.27                 |
| Anti-foam agent              | 0.005    | 0.073                |
| Flocculante                  | 0.004    | 0.049                |

Table 2 shows the quantitative and cost summary of the raw materials and materials required for the packing of asbestos boards in pallets of 60 pieces. For one transport, it is a mass of about 0.4 t of materials costing 0.48 thousand of zł.
Table 2. Raw materials and materials needed for packing asbestos plates, calculated as charge for a 24-ton vehicle

| Constituent material  | Mass (t) | price (thousands zł) |
|-----------------------|----------|----------------------|
| Wood (pallet)         | 0.398    |                      |
| Plastic wrap          | 0.012    | 0.481                |
| Plastic wrap          | 0.0004   |                      |

Table 3 summarizes energy consumption, gas, fibre discharge and fibre-cement waste production for 17.5 tonnes of asbestos plates (one cargo). Shows the activity, quantity and price of each item.

Table 3. Costs associated with the production of one asbestos board load

| Activity                        | Quantity | Price (thousands zł) |
|---------------------------------|----------|----------------------|
| Electricity consumption         | 8.42 GJ  | 0.580                |
| Propane gas consumption         | 0.58 GJ  | 0.032                |
| Fibre discharge                 | 0.15 kg  | -                    |
| Fibre-cement waste production   | 626.6 kg | 1.56                 |

Table 4 shows transportation costs. This is the average offer available on the market. This article assumes a fixed price per kilometre. In fact, at a greater distance, the unit cost may decrease. It depends on a service provider. The table assumes a range of 5 to 100 km because of the possibility of transportation even within the voivodships. The price for one kilometre was assumed at 3.00 zł.

Table 4. Transportation costs for one piece of asbestos material

| Obszar (km) | Price (zł) |
|-------------|------------|
| 5-20        | 15-60      |
| 21-50       | 63-150     |
| 51-70       | 153-210    |
| 71-100      | 213-300    |

Exactly the same way as in the case of transport looked the mechanism of selecting the price of disposal for a single asbestos plate. By comparing the market for available service providers, the weighted average of asbestos utilization was calculated. The calculation results are shown in Table 5.

Table 5. The cost of disposing of one piece of asbestos material

| Waste         | Mass (t) | Price (thousands zł) |
|---------------|----------|----------------------|
| End of life   | 24       | 4.8                  |

4. Conclusions

As it could be noticed from the above calculations, the cost of substrates necessary to produce asbestos sheets is the highest in terms of the whole life cycle of a product. This cost in the case of a 24-tonne vehicle is 13 882.00 zł and after conversion to a one tonne of finished product, it amounts to 793.30 zł. The next category is the cost of asbestos disposal, which equal 274.00 zł for the tonne of asbestos plates. The lowest cost to bear in the life cycle of asbestos boards is the cost of transport. Depending on the distance it could take a value from a range about 15.00 zł to 300.00 zł within one voivodeship.
The average cost of the whole lifecycle of a one tonne of asbestos plates, assuming an average transport distance of 50 kilometres, is therefore 1,917.30 zł. The sum of the costs for one cargo (on average distance) is 18,832.00 zł, and the price per ton of product is 1,076.10 zł.

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