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The Dissonances of Asbestos Exposure and the Concept of Sustainable Settlements in the Light of the European Union's 2023 Asbestos Neutrality Objective

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Until now, the majority of asbestos-related research has focused on the health challenges of asbestos and the waste management challenges caused by asbestos cement products. The limitation of the research is that there is no uniform indicator or index formation method available for asbestos exposure and involvement on a national scale. Given the neglect of the topic, there are no uniform risk assessment and situation assessment procedures available, neither, as a result, indicators or public databases. The aim of this paper is that, in parallel with the European Union's 2023 asbestos neutrality objectives, asbestos exposure is examined as a kind of indicator to assess the actual level of development of those member states that are progressing along the sustainable development goals. The focus of the paper is an analysis of the situation rather than the discovery of new scientific results. Using an integrated index formation method, the relationship between the indicators of sustainable development and the volume of asbestos consumption in the countries in the focus group is examined. It was established that the average value of the sustainable development index corrected for asbestos exposure in relation to the EU-27 is 0.428, which means a medium level of involvement. A comparison of the two indexes shows that there are significant differences. The average correction rate is -47.4 %. Based on the results and according to previous literature sources, asbestos exposure is an unexamined segment of efforts for sustainable development, which can also result in significant dissonances.

1. Introduction

Asbestos is a commercial term referring to a group of naturally occurring fibrous minerals (Wagner and Lemen, 2017), it is an ensemble of silicate minerals present in the environment as a natural bundle of fibers (Nieto et al., 2023). Asbestos is a group of six naturally occurring fibrous silicates known as chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite (Peña-Castro et al., 2023), each with different physicochemical properties (Fonseca et al., 2022) Asbestos is a commercial name for six fibrous materials that have many features made them attractive for many diverse uses in commercial and military products for fireproofing, automotive brakes, textiles, cement products, and wallboard material (Tulchinsky et al., 2023). Asbestos has remarkable durability and resistance to heat, properties conferring value in a wide range of products, including building and pipe insulation, friction products, including brake shoes, and fire-resistant bricks. Asbestos has been woven into fireproof cloth and incorporated into cement pipes used for water transport and into erosion-resistant cement roofing tiles (Wagner and Lemen, 2017). More than 50.0 % of asbestos sold worldwide was used in Europe between 1920 and 2000 (Paglietti et al., 2016). According to Ramazzini (2010), more than 90.0 % of the asbestos used was used in the form of various asbestos cement products, sheets, roofing materials, and pipes. The first asbestos-related health cases were reported in the 1950s, mainly among miners and factory workers dealing with asbestos (Jung et al., 2021). Since the 1960s, scientific evidence has shown a causal relationship between asbestos and carcinogenic effects in exposed individuals (Lin et al., 2019). Unfortunately, asbestos fibres are also inhalable and, once inhaled, cause a grave health risk, apparently because of their physical characteristics and biopersistence within the body. Asbestos exposure causes a wide range of serious and fatal health conditions, including cancer of the lung, mesothelioma, laryngeal cancers, and pulmonary fibrosis (Wagner and Lemen, 2017). Nowadays, asbestos is one of the most persistent genotoxins. It can

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stimulate DNA damage, cytotoxicity, and apoptosis. It promotes carcinogenesis, but it does not interact directly with DNA (Nieto et al., 2023). Although its use was banned in the EU approximately 20 - 30 years ago, asbestos can still be found in buildings, as it was widely used in the 20th century in the construction sector (Maduta et al., 2022). Currently, around 125 million people are exposed to asbestos in the workplace worldwide. Asbestos fibres fulfilling the "World Health Organisation (WHO)"-criteria (WHO-criteria: length L > 5 µm, diameter D < 3 µm, aspect ratio L:D > 3:1) are considered hazardous if inhaled or ingested (World Health Organization, 1997). In most EU countries, higher quantities of asbestos are expected in dwellings built between 1970 and 1990. However, in Cyprus, Belgium, Denmark, France, Luxembourg, The Netherlands, and Sweden it appears that dwellings dating before 1970 are at higher risk of having significant quantities of asbestos, while in Croatia, Slovenia, Slovakia and Romania, this risk is in newer residential buildings, built between 1990 and early 2000s (Maduta et al., 2022).

In 2016, about 80.0 % of the global population was living in countries without a total asbestos ban (Marsili et al., 2016). The problem of asbestos continued to be a subject of controversy. The policies related to asbestos pollution and loads are subject to many criticisms to this day. Criticisms included the failure of industry and government to act earlier on the adequacy of current concentration standards (Mannan, 2012). Two international Conventions are especially relevant to asbestos management (Lin et al., 2019). The first is the International Labour Organization (ILO) Convention No. 162 concerning Safety in the Use of Asbestos (International Labour Organization, 1986). The second is the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. The C162 Asbestos Convention focuses on the prevention of occupational exposure to asbestos. Among potential exposure scenarios, occupational exposure is associated with most asbestos-related diseases (Lin et al., 2019). Despite the fact that the manufacture and new use of these products have now been banned in many countries, the ban does not apply to the further use of previously installed products. Regarding the European Union, the picture is very mixed when it comes to asbestos removal. Some member states are very successful in coordinating it with the energetic renovation of buildings. In the European Union, two key pieces of legislation apply to asbestos: Directive 1999/77/EC: Prohibits the use of asbestos-containing materials in the workplace; Directive 2003/18/EC: Establishes asbestos-related health and safety standards in the workplace. Among the EU countries, only Poland has adopted an action plan for removal. This country has the best practice regarding the registration and removal of asbestos from existing buildings. The Asbestos Removal Program 2009-2032 which includes public and private funding, is decisive. An Asbestos database has been in use since 2013 (Long-Term Renovation Strategy of the Federal Government, 2018).

If asbestos is involved during the renovation, it is typically removed by adding support. In the case of some energy development, for example, the installation of a solar panel system, asbestos-freeness may be stipulated as a condition (Maduta et al., 2022). The objective of the European Union is to become asbestos-free by 2023. At the same time, achieving this presents extraordinary challenges, as there are significant differences in the individual policy instruments at the state level. Although the prohibition rules are the same, the regulations for removal may differ; some states have stricter regulations, while others have more lenient regulations. In addition, there are also significant differences in the measures taken for the sake of exemption objectives. In Belgium, it took 50 years, much longer than in neighbouring countries, for asbestosis to be recognised as an occupational disease (Nay, 2003). Van den Borre and Deboosere (2014) investigated diseases due to asbestos exposure and found that Belgium has one of the highest death rates from mesotheliomas in the world. The removal and disposal of asbestos is regulated at the regional level. In the Flanders region, for example, the exemption is verified with a certificate. In Germany, the proportion of buildings affected by asbestos is still estimated to be around 80 % (Long-Term Renovation Strategy of the Federal Government, 2018). Regarding the Netherlands, after the ban on the use of asbestos in 1993, the Dutch government initially ordered the removal of exterior materials containing asbestos on roofs, such as slate roofs and corrugated iron, by January 1. 2024. A study by (Duregger, 2021) reviews initiatives to remove asbestos roofs but concludes that there are no specific initiatives and management measures that work best. In January 2016, a national program supported the removal of asbestos roofs, but this was exhausted in 2018 (Long-Term Renovation Strategy of the Federal Government, 2018). In order to bridge the gap between international organisations' calls for action against asbestos use and current national efforts to ban asbestos altogether, it is crucial to understand whether national policies are in line with international conventions on the management and prohibition of asbestos (Lin et al., 2019), which should emerge as also in goals, such as the objectives of sustainable development. The indicators for sustainable settlements and communities do not include measures and monitoring settings for asbestos exposure and involvement. In general, it can be said that the number of European Union-level asbestos studies is extremely limited. The available literature deals with the topic only from the waste management or energy efficiency segments. Based on these, it can be definitely stated that this paper contains results of outstanding importance and fills in gaps. This paper enriches the literature related to the policy and contributes in a unique way to the European Union's innovative research on asbestos removal and asbestos exposure.

2. Materials and methods

The aim of this research is to calculate an alternative index that reveals the state of the European Union member states (EU-27) by 2022 regarding the population's exposure and the state's involvement to asbestos. The number of direct data related to asbestos is minimal, so both direct and indirect values were used in the calculation of this index. However, it must be emphasised that the amount of publicly accessible data in this regard is minimal. The index formation method used is a procedure suitable for uniform handling of multidimensional data, which results in a dimensionless value between 0.00 and 1.00. The range of indicators used consisted of the following: estimated average quantity of asbestos in the residential building stock across the age bands (Maduta et al., 2022) and the SDG index scores of each EU-27 member state. The examined year is 2022. The current index formation is aimed at exploring the situation for the year 2022. The elements of the taxonomic assessment used to determine the integral index of asbestos involvement were the same as Oliinyk et al. (2023) with the method used.
Eq(1): Standardization of initial data with different units and dimensions in order to reduce them to a single metric scale, using the following formula: (1), where Z_{ij} is the standardised value of the i-th indicator of the j-th EU-27 state ($i = \overline{1.n};\ j = \overline{1.m}$); x_{ij} the arithmetic mean value of the i-th indicator of the j-th EU-27 state; σ_i is the standard deviation value of the i-th indicator.

$$Z_{ij} = \frac{x_{ij} - \bar{x}_{ij}}{\sigma_i}, \tag{1}$$

Eq(2): Creation of reference point Z_{0i} ($Z_{01}.Z_{02}....Z_m$), which means comparing the values of the EU-27 states to the maximum value of the given value series (2).

$$Z_{0i} = \max z'_{ij}\ i \text{ € } I, \tag{2}$$

Where: I is the set of indicators.
Eq(3): Determination of the Euclidean distance, which shows the distance of the indicators relative to a given reference point (3), where: d_{0i} is the Euclidean distance of the indicator value from the reference point.

$$d_{0i} = \sqrt{\sum_{i,j=1}^{n,m} (Z_{ij} - Z_{0i})^2}, \tag{3}$$

Eq(4): Calculation of the taxonomic index of the integral index, which reflects the alternative measure of the corrected SDG index with asbestos involvement and exposure of the EU-27 states (K_i) with formula (4), where: K_i is the picture of the given level of asbestos involvement in each EU-27 state; $\overline{d_0}$ is the arithmetic mean of the corresponding Euclidean distance; σ_0 is the standard deviation of the corresponding Euclidean distance.

$$K_i = 1 - \frac{d_{0i}}{d_0},\ d_0 = \overline{d_0} + 2 \cdot \sigma_0, \sigma_0 = \sqrt{\frac{\sum (d_{0i} - \overline{d_0})^2}{n}}, \tag{4}$$

3. Results

There is no methodology available for a complex and interdisciplinary assessment of asbestos involvement and exposure in individual countries. Since the range of available data is limited, and monitoring for asbestos does not work in any state, individual evaluations can be carried out based on subjectively selected indicators. After sorting and standardising the data of the selected indicators after categorising the individual data, the measure of the Euclidean distance values was established, which was followed by the calculation of the alternative dimensionless index (Table 1). The calculated index makes it possible to rank each member state based on the fact that it simultaneously takes into account the SDG index value of each country and the size of the average amount of asbestos found in buildings. Regrettably, the indicators of the objectives of sustainable development do not address in any way the extent of possible asbestos exposures, nor the size of the affected population, housing stock, sewer network, or poverty rate.
Based on the primary and secondary data obtained during the taxonomic analysis, it can be established that the value of the member states of the European Union varied in the year 2022. The average value of the calculated index was 0.428. Denmark had the highest value (0.882), followed by Finland (0.814), Estonia (0.660), Czechia (0.659) and Germany (0.637).

Table 1: Results of Euclidean distance and integral index calculation

State	Asbestos in the residential buildings - average (kg/dwelling)	SDG index score: 2022	Asbestos in the residential buildings - standardized (kg/dwelling)	SDG index score – standardized: 2022	$\sum(d_{0i}-d_0)^2$	Euclidean distance	K_i
Belgium	240.0	79.46	1.3071	-0.2135	4.94	2.22	**0.511**
Bulgaria	90.5	74.62	-0.8394	-1.6869	18.26	4.27	**0.060**
Czechia	210.5	81.87	0.8836	0.5201	2.40	1.55	**0.659**
Denmark	210.5	85.68	0.8836	1.6799	0.29	0.54	**0.882**
Germany	150.5	83.36	0.0221	0.9737	2.72	1.65	**0.637**
Estonia	240.0	81.68	1.3071	0.4623	2.39	1.55	**0.660**
Ireland	75.5	80.15	-1.0548	-0.0035	9.63	3.10	**0.317**
Greece	90.5	78.37	-0.8394	-0.5453	11.13	3.34	**0.266**
Spain	90.5	80.43	-0.8394	0.0817	8.32	2.88	**0.365**
Portugal	103.63	82.05	-0.6509	0.5749	5.89	2.43	**0.466**
France	60.0	81.50	-1.2774	0.4075	9.24	3.04	**0.331**
Croatia	150.5	78.79	0.0221	-0.4175	7.54	2.75	**0.396**
Italy	240.0	72.49	1.3071	-2.3353	18.87	4.34	**0.044**
Cyprus	240.0	80.68	1.3071	0.1578	3.43	1.85	**0.593**
Latvia	240.0	76.81	1.3071	-1.0202	9.17	3.03	**0.333**
Lithuania	210.5	77.65	0.8836	-0.7645	7.87	2.81	**0.383**
Luxembourg	210.5	79.39	0.8836	-0.2348	5.21	2.28	**0.498**
Hungary	60.0	75.53	-1.2774	-1.4099	18.37	4.29	**0.057**
Netherlands	90.5	79.42	-0.8394	-0.2257	9.60	3.10	**0.318**
Austria	171.0	82.28	0.3164	0.6449	2.84	1.69	**0.629**
Poland	121.0	81.80	-0.4015	0.4988	5.20	2.28	**0.498**
Malta	90.5	80.02	-0.8394	-0.0431	8.82	2.97	**0.347**
Romania	63.88	77.46	-1.2217	-0.8224	14.41	3.80	**0.165**
Slovenia	60.0	81.01	-1.2774	0.2583	9.74	3.12	**0.313**
Slovakia	240.0	79.12	1.3071	-0.3170	5.41	2.33	**0.488**
Finland	181.0	86.76	0.4600	2.0087	0.72	0.85	**0.814**
Sweden	90.5	85.98	-0.8394	1.7712	4.66	2.16	**0.525**

Data from: Maduta et al. (2022); Sachs et al. (2023); SDG index score: dashboards.sdgindex.org/profiles

Cyprus had the lowest value (0.044). Malta (0.057), Bulgaria (0.060), Romania (0.165) and Greece (0.266) also had low values. Hungary was in 10th place with an above-average value of 0.498. The map shown in Figure 1 illustrates and compares the individual countries along the calculated integral index in relation to the EU-27. If, in addition to indexing, the national values of the examined indicator are also compared, it is possible to group the individual countries differently. SDG index above 80.0 and asbestos exposure above 200 kg/dwelling were typical for the following countries: Denmark, Czech Republic, Estonia and Latvia.

A high asbestos exposure value was typical, but at the same time it had a lower (< 80.0) SDG index value: Hungary, Luxembourg, Belgium, Slovakia, Lithuania and Cyprus. Sweden is the only country that produced an SDG index above 85.0 below 100 kg/dwelling. Apart from it, the following countries also received an index above 80.0 with this involvement value: Croatia, Slovenia, Spain, Portugal, Ireland. With the two smallest values - involvement under 100 kg/dwelling and an SDG index under 76.0 - Malta and Bulgaria. If exposure to asbestos is not taken into account, the average SDG index value in 2022 was 80.2 in the EU-27.

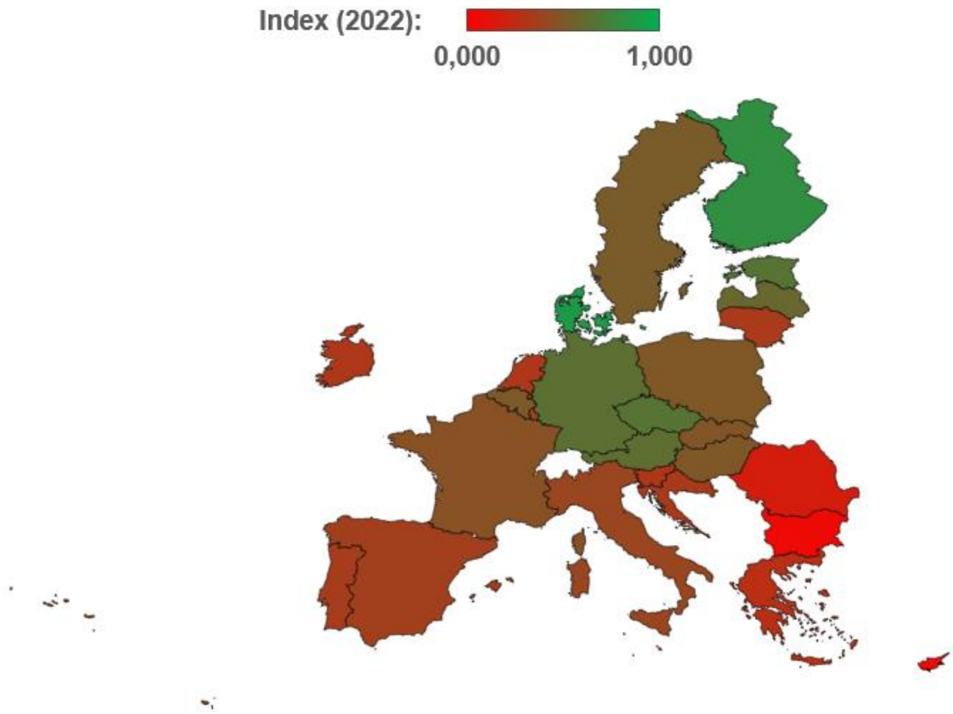

Figure 1: Comparison of calculated integral index values in EU-27; Data from: own calculated, own edited

At the same time, taking asbestos exposure into account, the average development value changes to 42.8. According to the calculations, this means a decrease of almost -46.6%. If the results of the evaluation obtained by the SDG index and the integral index are compared, significant decreases in the magnitude of the values can be detected in some member countries. A comparison of the previous SDG index and the calculated value shows that there are significant differences. The average correction rate is -47.4 %. The biggest decliners: Bulgaria (-92.0), Malta (-92.5) and Cyprus (-93.9 %). In the case of Hungary, the rate of decrease is -37.3 %.

4. Conclusions

The aim of this paper is to draw attention to the neglect of asbestos exposure in the case of sustainable development goals. Exploring the involvement and exposure of individual territorial units can be approached in a number of ways, but at the same time, it is an extremely difficult task. The concept of sustainable settlements does not examine the asbestos involvement of the building stock and settlement infrastructure at all. This paper focuses on the average amount of asbestos found in the buildings of each state and the progress of the same state's sustainable development goals. During the research, the taxonomic method was used, whose decisive function is the number and quality of the indicators. It was established that the average value of the sustainable development index corrected for asbestos exposure in relation to the EU-27 is 0.428, which means a medium level of involvement. A comparison of the previous SDG index and the calculated value shows that there are significant differences. The average correction rate is -47.4 %. Based on the research results, it can be confirmed that significant dissonances can be observed in the value of the SDG index and the level of asbestos exposure in some EU-27 member states. In our opinion, this research should be continued. The research on the situation of asbestos involvement is a current topic that fills a gap, which depends to a large extent on the quality, quantity, and availability of the collected indicators and data. The results are applicable and can serve as a starting point for future research. The focus of future research may be to increase the efficiency of asbestos removal and risk assessment. One important direction of this can be the creation of multidimensional indicators and the exploration of interactions between different levels of involvement.

References

Duregger N., 2021, The asbestos roofing issue: An assessment of initiatives and governance arrangements for the removal of asbestos roofs in The Netherlands, Master thesis, Rijksuniversiteit Groningen, Netherlands.

Long-Term Renovation Strategy of the Federal Government, 2018, Pursuant to Article 2a of Directive (EU) 2018/844 of the European Parliament and of the Council amending Directive 2010/31/EU on the energy performance of buildings (Energy performance of buildings directive, EPBD 2018).

Fonseca A.S., Jørgensen A. K., Larsen B. X., Moser-Johansen M., Flachs E. M., Ebbehøj N. E., Bønløkke J. H., Østergaard T. O., Bælum J., Sherson D. L., Schlünssen V., Meyer H. W., Jensen K. A., 2022, Historical Asbestos Measurements in Denmark—A National Database. International Journal of Environmental Research and Public Health, 19(2), 643, 1–17.

International Labour Organization, 1986, C162 Asbestos Convention, 1986 (no 162): convention concerning safety in the use of asbestos (entry into force 16 June 1989).

Jung H.-S., Jang J., Park E.-K., Cho Y., Lee J.-C., Kim H., 2021, Changes in concentrations and characteristics of asbestos fibers dispersed from corrugated asbestos cement sheets due to stabilizer treatment, Journal of Environmental Management, 285, 112110.

Lin R. T., Chien L. C., Jimba M., Furuya S., Takahashi K., 2019, Implementation of national policies for a total asbestos ban: a global comparison, The Lancet Planetary Health, 3(8), 341–348.

Maduta C., Kakoulaki G., Zangheri P., Bavetta M., 2022, Towards energy efficient and asbestos-free dwellings through deep energy renovation, Identification of vulnerable EU regions, EUR 31086 EN, Publications Office of the European Union, Luxembourg.

Mannan S., 2012, Toxic Release, Chapter In: Mannan S. (Ed), Lees' Loss Prevention in the Process Industries, Butterworth-Heinemann, Oxford, 1679–1760.

Marsili D., Terracini B., Santana V. S., Ramos-Bonilla J. P., Pasetto R., Mazzeo A., Loomis D., Comba P., Algranti E., 2016, Prevention of asbestos-related disease in countries currently using asbestos, International Journal of Environmental Research and Public Health, 13(5), 1–19.

Nay S. Y., 2003, Asbestos in Belgium: Use and Abuse, International Journal of Occupational and Environmental Health, 9(3), 287–293.

Nieto M.-B., García-Fernández A. J., Navas I., 2023, Asbestos, Reference Module in Biomedical Sciences, Elsevier, Amsterdam.

Oliinyk O., Mishchuk H., Vasa L., Kozma K., 2023, Social Responsibility: Opportunities for Integral Assessment and Analysis of Connections with Business Innovation, Sustainability, 15(6), 5608, 1-17.

Paglietti F., Malinconico S., della Staffa B. C., Bellagamba S., De Simone P., 2016, Classification and management of asbestos-containing waste: European legislation and the Italian experience, Waste Management, 50, 130–150.

Peña-Castro M., Montero-Acosta M., Saba M., 2023, A critical review of asbestos concentrations in water and air, according to exposure sources, Heliyon, 9(5), e15730.

Ramazzini C., 2010, Asbestos Is Still With Us: Repeat Call for a Universal Ban, Archives of Environmental & Occupational Health, 65(3), 121–126.

Sachs J. D., Lafortune G., Fuller G., Drumm E., 2023, Implementing the SDG Stimulus. Sustainable Development Report 2023, Paris: SDSN, Dublin: Dublin University Press, 1-546.

Tulchinsky T. H., Varavikova E. A., Cohen M. J., 2023, Environmental and occupational health, The New Public Health. Academic Press / Elsevier, London United Kingdom, 681–750, DOI: 10.1016/B978-0-12-415766-8.00009-4.

Van den Borre L., Deboosere P., 2014, Asbestos in Belgium: an underestimated health risk, The evolution of mesothelioma mortality rates (1969–2009). International Journal of Occupational and Environmental Health, 20(2), 134–140.

Wagner G.R., Lemen R.A., 2017, Asbestos, Chapter In: Quah S. R. (Ed.), International Encyclopedia of Public Health, Academic Press, Cambridge, United Kingdom, 176–182.

World Health Organization, 1997, Determination of airborne fibre number concentrations: a recommended method, by phase contrast optical microscopy (membrane filter method), Environment, Climate Change and Health, Geneva, Switzerland, ISBN: 9241544961, 1-53.