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EXPERIENCES IN ASBESTOS-CONTAINING WASTE MANAGEMENT IN THE REPUBLIC OF CROATIA

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SUMMARY: This paper presents an overview of asbestos production data worldwide and in the Republic of Croatia in the period 2000 to 2018 as well as the asbestos consumption data from 1995 to 2010. The results of asbestos waste collection from 1995 to 2018 have been analyzed and the experiences of the Republic of Croatia in the management of asbestos-containing waste have been described in accordance with the applicable national legislation. Although asbestos does not pose a risk if its products do not become damaged by fracture, or during transportation or decomposition, it poses a potential danger to human health. In today's world, every five minutes someone dies from a disease related to asbestos, such as asbestosis and cancer caused by asbestos. For these reasons, most countries adopted the obligation to execute a series of measures to stop using asbestos in 1999, while at the same time in the Republic of Croatia still imported about 4000 tonnes of asbestos per year. In 2006, the Republic of Croatia banned the production, transport, and use of asbestos, and the asbestos objects whose lifetime expired ended up in municipal waste, causing the need for special regulations in order to arrange the management of asbestos containing waste. Over the past ten years, the Republic of Croatia has developed an asbestos waste management system. Regardless of the success of its application, certain improvements are needed, as data on the amounts of reported construction waste, and thus the part containing asbestos, do not coincide with economic and other indicators for the construction sector.

Key words: *asbestos, health risk, waste management, legislation*

INTRODUCTION

A healthy environment is a basic prerequisite for the preservation of human health and life quality, and the most common adverse environmental impacts on human health are related to poor water quality, air pollution, waste management problems, etc. The impact of climate change has also been recently observed, while the loss of biodiversity and land degradation indirectly affect the reduction of life quality. The health effects of hazardous substances are less widely known, and in urban and traffic areas, these substances, along with noise, have a significant harmful effect on human health and safety.

Human health is directly related to the health of the environment because pollution or contamination of the environment may be the cause of a number of health problems, such as asthma, allergy or hypersensitivity, various forms of cancer, diabetes, heart and vascular system diseases, problems with fertility, neurological conditions, obesity and many others. Unfortunately, many of the health consequences of environmental pollution are only apparent after a long time or come as a result of chronic exposure. Although the harmful impact of environmental pollution on

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human health has long been known, and although health is the value to which most people attach the greatest significance, the measures aimed at ensuring a cleaner and healthier environment are often still viewed as difficult-to-obtain luxury and are sometimes not considered a priority.

One of the many pollutants in the environment, classified as a dangerous substance, is asbestos. Because of its physicochemical properties, this mineral was widely used in the manufacture of various products in the last century, to achieve good mechanical and chemical properties such as resistance to moisture, high temperature, noise, electricity, wear and friction. It was added to other mineral raw materials, which were mainly used for the production of roof panels, insulating materials, bricks, asbestos cement pipes, gaskets, laboratory gloves, high temperature protective suits, etc.

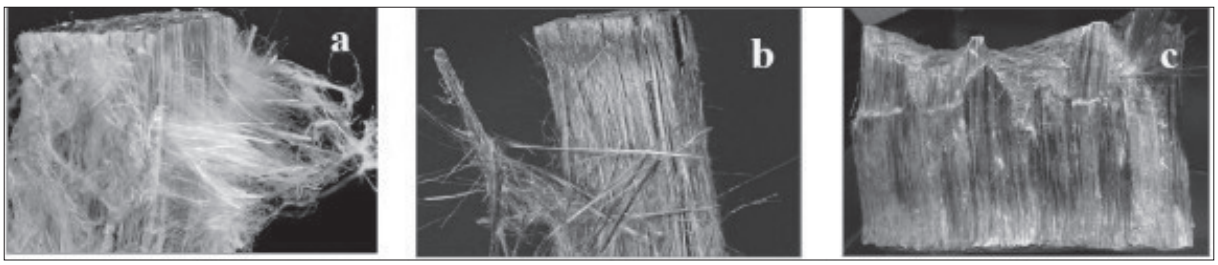
Due to the developed awareness of the harmfulness of the various materials that surround us and the improved legal and other regulations governing these issues, the production and use of asbestos and asbestos products have been prohibited. Nevertheless, we still face environmental concerns with this dangerous pollutant being released from items that are still in use. It mainly refers to the straight and/or wavy panels on our roofs or replaced asbestos roofing sheets, which along with other items withdrawn from use make waste identified under the waste code 17 06 05 * (construction materials containing asbestos), or other objects that are sorted out under the waste code 17 06 01 * at the end of their lifetime, consisting of asbestos containing insulating materials *(Ordinance on Waste Catalogue, OG No. 90/15)*. This type of waste is usually generated during the construction, restoration and maintenance of construction facilities replacing roof asbestos panels. Their collection, transport and disposal require great attention and compliance with existing legal and other regulations.

ASBESTOS AND ITS USE

Asbestos (Ancient Greek: ἄσβεστος = *forever*) is the name for a group of natural mineral fibers of calcium, magnesium and iron silicates, odorless, tasteless and usually visible only microscopically. Namely, the fibers are microscopically thin, so only those fibers that are as thick as a human hair (40 μm) are visible to the naked eye. They are present in the stacks of about 2 million fibers which, because of their mechanical characteristics, break longitudinally and transversely, forming yet thinner fibers similar to needles. These even finer fibers are light and float in the air, and since they are not visible and have no smell, they are easy to breathe in and end up in the lungs *(Miklič-Milek et al., 2016, Environmental Health Criteria (EHC) 53, 1986)*.

This group of minerals has exceptional physical and chemical properties because they are non-combustible, heat-stable (up to 1000 °C), insoluble in water and organic solvents, non-biodegradable, chemically inert in many aggressive chemicals, have low electrical conductivity, good electrical and thermal insulating properties, good spinning ability, high elasticity and tensile strength, and they are easy to mix with binder materials *(Miklič-Milek et al., 2016, Environmental Health Criteria (EHC) 53, 1986, Miller, 2017, Fuk, 2016)*.

Asbestos is naturally occurring in the form of minerals that are crystalline, with fibrous structure, belonging to the serpentine or amphibole group. It is found in six basic types of silicates, such as crocidolite or *blue* asbestos $[NaFe^{2+}{}_3Fe^{3+}{}_2Si_8O_{22}(OH)_2]_n$, actinolite, $[Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2]_n$, anthophillite $[(Mg,Fe^{2+})_7Si_8O_{22}(OH)_2]_n$, chrysotile or *white* asbestos $[Mg_3Si_2O_5(OH)_4]_n$, amosite or *brown* asbestos $[(Mg,Fe^{2+})_7Si_8O_{22}(OH)_2]_n$ and tremolite $[Ca_2Mg_5Si_8O_{22}(OH)_2]_n$. Of these six basic types of asbestos *(IARC, 2012)*, chrysotile, crocidolite and amosite were most frequently used for commercial purposes, and today they are most represented as pollutants in the environment, Figure 1 *(Gibson, 2017)*.



(a) (b) (c)

Figure 1. Most commonly used types of asbestos; a) chrysotile (white), b) crocidolite (blue) and c) amosite (brown)
Slika 1. Najčešće korišteni tipovi azbesta; a) krizotil (bijeli), b) krokidolit (plavi) i c) amozit (smeđi)

Use of asbestos from antiquity to the present

Asbestos occurs in nature on all continents and is used for various purposes from the earliest days of human activity. Archaeologists have discovered asbestos fibers in the remains since the Stone Age, some 750,000 years ago, and it is believed that 4,000 years BC, asbestos fibers were used for making wicks in lamps and candles *(Mesothelioma Center)*. According to some sources *(Mesothelioma Hope, Vučinić et al., 2007)* it was determined that asbestos was used 8,000 BC in Scandinavia as a supplement to the clay to make dishes because the potters of the time were aware of its resistance to heat.

Between 2,000 and 3,000 BC, the Egyptians and Romans used asbestos cloth for the purpose of making objects for general use, and in the 11th century it was also used by the crusaders. During the 17th and early 18th centuries, during the rule of the Russian emperor Peter the Great, asbestos was also used in Russian castles. At the beginning of the industrial revolution, asbestos production bloomed with the start of the commercial use of asbestos and its multiplicity of application became widespread.

The modern asbestos industry began in the early 1800s when textile industry producing asbestos items such as fabrics, ropes, materials for bookbinders, etc. was established in Italy *(Virta, 2006)*. Asbestos consumption at that time was still extremely low compared to its use in the 20th century. With the rise in industrialization, new possibilities for the use of asbestos have been discovered owing to its properties such as heat resistance and the flexibility of asbestos fibers. This primarily refers to the application of asbestos as insulation material widely used in the production of steam generators, but it begins to be used in construction.

At the beginning of the 1900s, asbestos production in the world grew to more than 30,000 tonnes per year *(Mesothelioma Center)*. Unfortunately, with the development of mining and asbestos production and its wide application, its harmful impact on the health of those who were in contact with it also started.

In 1907, the development of technology for the production of asbestos-cement flat and wavy panels significantly increased demand for asbestos. This technology enabled mass production of cheap, fireproof construction materials. Twenty years later, the process of the production of asbestos-cement pipes was developed, enabling wide application of asbestos materials in water supply and drainage. At the same time, with the growth of the automotive industry, demand for asbestos increased due to already commercialized production of brakes, couplings and engine gaskets. This technological advancement in the application of asbestos also resulted in the accelerated growth of its demand on the world market. Consequently, its production grew and by 1910 it exceeded 109,000 tonnes, which is more than three times higher than in 1900 *(Virta, 2006)*. Asbestos production and consumption was decreased during the economic crisis of the 1930s and during World War II, but after that, the situation significantly changed almost instantly. The peak of world's asbestos needs was reached in the 1970s when it was its largest production level, ranging from 3.5 mln tonnes (1970) to 4.8 mln tonnes (1977), which is also the world's at largest annual asbestos production ever *(Virta, 2006)*.

The fall in production of asbestos began in the late 1970s, when the use of asbestors items started decreasing because of the awareness of its harmful effects on human health. That was the time when more stringent measures were taken regarding the professional exposure of asbestos and limiting its use. At the same time, more and more legislation on the limitation of asbestos consumption and protection of the environment from its harmful effects was adopted, which in 2003 led to the total or partial prohibition of asbestos use in 16 countries - Argentina, Austria, Belgium, Chile, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Poland, Saudi Arabia, Sweden, Switzerland, and the United Kingdom.

As for the European Union (EU), the European Parliament adopted Council Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations in 1976 *(Council Directive 76/769/EEC, 1976)*. This Directive ordered that all EU member states should abandon and completely prohibit the use of certain hazardous substances including asbestos by the beginning of 2005 and harmonize their acts and regulations with this Directive by April 15th 2006. This issue was also covered by Directive 2003/18/EC of the European Parliament and of the Council of March 27th 2003 amending Council Directive 83/477/EEC on the protection of workers from the risks related to exposure to asbestos at work *(Directive 2003/18/EC, 2003)*. On the basis of this, in Croatia, a regulation prohibiting use, production, and transport of asbestos products included in the List of poisons whose manufacture, trade and use are forbidden in Croatia was adopted by the competent ministry in early 2006 *(OG No. 29/05)*.

Use of asbestos in the world and in the Republic of Croatia

As health risks associated with the use of asbestos became more and more recognizable, the use of this dangerous substance began to decline, primarily because some countries adopted the appropriate prohibition of use of all forms of asbestos for industrial and other purposes. The first countries to do that were Iceland and Sweden. The benefits of stopping the use of this dangerous substance are apparent as evidenced by data from Sweden and the Netherlands, showing the rates of cancer deseases caused by asbestos (mesothelioma) steadily decreasing over the past 30 years, since these countries prohibited the use of asbestos, while unfortunately, in countries where the use of this hazardous substance is still permitted, there is scientific evidence of an increase in the number of these diseases *(Frank et al., 2014)*. Currently, more than 60 countries have prohibited the use of asbestos, although this is not the case in the United States and India, which is obviously a consequence of economic policies or insufficient ecological awareness. An illustrative example is Canada, which exploited asbestos sites for years and exported it in huge quantities even at a time when its use in Canada was virtually zero. Canada finally closed its asbestos mines in Quebec in 2012 *(Frank et al., 2014)*.

In the 1980s, due to the established detrimental effect of asbestos on human health, its production and use decreased significantly, so global consumption of 4.7 million tonnes (1980) fell to around 2 million tonnes in the late 90s *(Virta, 2006)*. At the beginning of this century, annual asbestos production in the world ranged to about 2 million tonnes, while at the same time its consumption in most countries fell, Figure 2 *(National Minerals Information Center)*.

Between 2000 and 2018, Russia, China, Canada, Kazakhstan, and Brazil were among the most significant producers of asbestos and exporters in the world, Table 1 *(National Minerals Information Center)*.

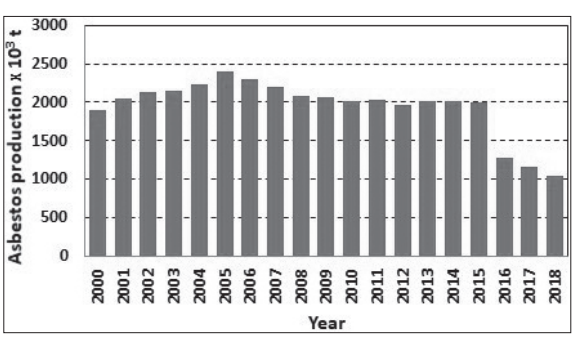


Figure 2. Trends in the world asbestos production in the period 2000-2018

Slika 2. Kretanje svjetske proizvodnje azbesta u razdoblju 2000.- 2018. godine

Table 1. Annual asbestos production in some countries in the period 2000-2018

Tablica 1. Godišnja proizvodnja azbesta u nekim zemljama u razdoblju 2000.-2018.

State	Asbestos production, t/a								
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Brazil	170,000	170,000	209,000	195,000	195,000	195,000	236,000	230,000	255,000
China	260,000	360,000	360,000	260,000	355,000	520,000	350,000	380,000	280,000
Canada	307,000	277,000	242,000	240,000	220,000	185,000	200,000	180,000	160,000
Kazakhstan	125,000	235,000	291,000	353,000	347,000	355,000	355,000	300,000	230,000
Russia	750,000	750,000	750,000	878,000	875,000	925,000	925,000	925,000	1,020,000
WORLD	1,900,000	2,050,000	2,130,000	2,150,000	2,230,000	2,400,000	2,300,000	2,200,000	2,090,000

State	Asbestos production, t/a									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Brazil	288,000	270,000	306,000	305,000	291,000	311,000	311,000	200,000	160,000	100,000
China	380,000	400,000	385,000	420,000	420,000	410,000	400,000	200,000	125,000	100,000
Canada	150,000	100,000	50,000	ND	ND	ND	ND	ND	ND	ND
Kazakhstan	230,000	214,000	223,000	241,000	243,000	213,000	215,000	193,000	193,000	193,000
Russia	1,000,000	1,000,000	1,031,000	1,050,000	1,100,000	1,100,000	1,100,000	692,000	690,000	650,000
WORLD	2,070,000	2,010,000	2,030,000	1,970,000	2,020,000	2,020,000	2,000,000	1,280,000	1,168,000	1,043,000

ND - no data

Three decades after the discovery of the harmful effects of asbestos on human health, which is the reason why asbestos items have been less used, this dangerous substance is still in use in the world, and the leaders of its use are Brazil, China, India, Iran, Kazakhstan, Russia, Thailand, and Ukraine. Each of these countries consumes more than 75,000 tonnes per year, which in 2003, for example, accounted for more than 82% of the world's asbestos consumption. Unfortunately, in some countries, such as in Azerbaijan, China, India, Iran, Kazakhstan, Thailand, and Ukraine, asbestos consumption was even increasing considerably in the early 2000s, Table 2 *(National Minerals Information Center, Virta et al., 2006)*.

Although the production of asbestos items in Croatia has a long tradition, because asbestos had been used since 1921 as an additive to the raw material in Vranjica's construction material production plant, its massive application actually began immediately after World War II. That is when Croatia began intensively to import, process, and use asbestos in shipyards and factories of asbestos-cement products. At the time, harmful effects of asbestos on human health have already been known to the extent that measures to protect the employees with occupational exposure began to implement. At the same time, Croatian shipbuilding was one of the leading domestic industries and the largest national consumer of asbestos.

Table 2. Annual increase of asbestos consumption in some countries in the period 2001-2007

Tablica 2. Porast godišnje potrošnje azbesta u nekim zemljama u razdoblju 2001.-2007.

State	Annual consumption, t/a						
	2001	2002	2003	2004	2005	2006	2007
China	394,324	378,457	492,000	537,000	515,000	541,000	626,000
India	150,161	168,292	192,000	190,000	255,000	240,000	302,000
Thailand	103,320	109,684	133,000	166,000	176,000	141,000	86,500
Kazakhstan	214,298	175,584	174,000	289,000	150,000	96,200	109,000
Byelorussia	1,585	ND	ND	21,000	21,900	24,800	33,300
Pakistan	464	1,530	3,130	9,170	8,390	6,990	3,680

ND - no data

Table 3. Annual consumption of asbestos per capita in some countries in the world and in EU in the period 1950-2010

Tablica 3. Kretanje godišnje potrošnje azbesta po stanovniku u nekim zemljama u svijetu i EU u razdoblju 1950.-2010.

State	Annual consumption, kg/capita/a						
	1950s	1960s	1970s	1980s	1990s	2000s	2010s
USA	3.82	3.32	2.40	0.77	0.08	0.01	0.00
Japan	0.56	2.02	2.92	2.66	1.81	0.46	0.00
Brazil	0.27	0.38	0.99	1.25	1.07	0.74	0.88
Germany	1.84	2.60	4.44	2.43	0.10	0.00	0.00
Norway	1.38	2.00	1.16	0.03	0.00	0.00	0.00
Poland	0.36	1.24	2.36	2.09	1.05	0.01	0.00
Hungary	0.76	1.23	2.87	3.29	1.50	0.16	0.03
Austria	1.16	3.19	3.92	2.08	0.36	0.00	0.00
Croatia	0.39	1.13	2.56	2.36	0.95	0.65	0.39

According to literature data *(Virta et al., 2006, Kameda et al., 2014, IARC, 2009)*, the annual consumption of asbestos per capita in Croatia ranged from 0.39 kg (1950s) to 2.56 kg (1970s) when it started to fall for the above reasons and at the beginning of this century it dropped to just 0.65 kg , i.e. 0.39 kg per capita in 2010s, Table 3 *(Virta et al., 2006, Kameda et al., 2014, IARC, 2009)*.

At the same time, Croatian production of asbestos decreased from 19,242 tonnes in 2000 to 7,699 tonnes in 2006, when its production in the Republic of Croatia stopped *(Habuš et al., 2013)*. Although the production of asbestos items in Croatia was stopped, these products were unfortunately still imported into the country, in annual quantities ranging from 5,900 tonnes (2006) to 1,550 tonnes (2008), after which the imports fell sharply due to restrictions on the use of asbestos products to only a few hundred tonnes *(Trošić, 2009, Mesothelioma Center)*. The number of pro-

ducts made of or containing asbestos in large or small quantities was very large and used for various purposes, and some of the most commonly used products are shown in Table 4 *(Trošić, 2009, Mesothelioma Center, Asbestos Network, Taylor, 2007)*.

With regard to the very widespread use of asbestos for making various items of general use as well as items that had a special purpose, Figure 3, it was to be expected that these objects would appear as waste after usage. Namely, at the end of the lifetime of such items, they often ended up in municipal solid waste or a special category of waste generated in the construction, renovation or maintenance of buildings or similar structures, where asbestos-containing construction elements were used.

Table 4. Some of the most common products made of or containing asbestos

Tablica 4. Neki od najčešćih proizvoda izrađenih od azbesta i proizvoda koji sadrže azbest

No.	Product
1.	Plumbing concrete-asbestos pipes
2.	Roof tile, brick, support armatures
3.	Floor tiles and reinforced floor coverings
4.	Acoustic insulation (plaster)
5.	Thermal/electrical insulation strips
6.	Carpets, ceiling panels
7.	Paints
8.	Flat and wavy roof panels
9.	Roof shingle
10.	Working protective gloves
11.	Working protective aprons
12.	Working protective clothing (workers on the casting of iron and steel)
13.	Brake plates of cars, wagons and elevators, ...

Figure 3. Some of the most commonly used asbestos products or products with the addition of asbestos (Shree Firepack Safety PVT LTD)

Slika 3. Neki od najčešće korištenih proizvoda izrađenih od azbesta ili uz dodatak azbesta (Shree Firepack Safety PVT LTD)

In the period between 2001 and 2012, Europe spent 7.8 million tonnes of asbestos which accounted for about 31% of the total world consumption, which is a relatively large amount compared to the population. However, the average asbestos consumption in general has decreased, and in relation to the period from 1971 to 2000, it dropped from 3.1 kg/capita/year to 0.7 kg/capita/year in the period 2001-2012 *(Kameda et al., 2014)*.

Asbestos waste was generated in other industrial branches as well, especially when replacing worn out asbestos gaskets, insulation materials, protective clothing, and other items. After the harmfull effects of asbestos from waste containing this hazardous substance have been established, the need for specific regulations on the safe management of this waste, i.e. its collection, transport and, disposal was imposed, which requires a lot of attention.

EXPERIENCES OF THE REPUBLIC OF CROATIA IN WASTE MANAGEMENT CONCERNING ASBESTOS

In the last century, asbestos was one of the great economic-industrial, health-social and environmental problems. Since it was found everywhere in the environment, its impact on human health has left an indelible mark, because it was released from the material from a series of procedures of restoration, demolition,

maintenance and construction and then it was dispersed in the air in the form of fine particles that humans were inhaled.

In spite of all its positive characteristics for which it came to very wide application, asbestos also has adverse properties, i.e. it is harmful the human health and life. Studies have shown that prolonged contact with asbestos causes severe chronic illness and death. Such high mortality and illness rates caused by asbestosis and cancer were exactly the reason why experts of World Health Organization (WHO), International Labor Organization (ILO) and the International Agency for Research on Cancer (IARC) proposed a ban on asbestos use in the late 1980s.

Namely, if asbestos is in good condition and not damaged, then it is safe as long as the asbestos-containing material is not defect and the air does not reach tiny asbestos fibers size (<100 microns), because then it becomes very harmful in all its forms (crocidolite, amosite, anthophillite, tremolite, chrysotile).

In today's world, every five minutes someone is dying of an asbestos-related disease. The statistic data from the EU expert reports point to the scariest extent of this problem and predict that 500,000 people in the EU will die of cancer related to human exposure to asbestos by 2030. At the same time, more than 100,000 people per year die from these diseases worldwide, although in most countries the use of asbestos is forbidden *(Miklič-Milek et al., 2016)*.

These facts point to the necessity to approach the management of asbestos containing waste very seriously, because regardless of the quantities that have so far been generated and collected in a less or more effective way, and having in mind its almost centuries-old use, this type of waste will be appearing in our environment for many years to come.

The results of the collection of asbestos containing waste 1995-2008

Back in the 1970s, some environmental issues were regulated in the Republic of Croatia within the Act on Physical Planning and Use of Construction Land *(OG No. 14/73)*, which did not govern any waste issues, so in 1982 a special Waste Treatment Act was adopted *(OG No. 42/82)*, according to which waste materials were considered waste in solid, liquid and gaseous conditions arising in the process of production, transport, use and biological reproduction. The waste materials were then grouped into four groups: waste from production and transport, waste mineral and other oils, communal waste and unused energy. According to the same Act, communal waste consists of:

- waste from household and commercial activities, administrative institutions and markets;
- bulky waste;
- street waste;
- construction material: solid, earth, mixed waste from the construction sites;
- garden and green waste from parks and cemeteries.

Official data on the amount of waste generated in the Republic of Croatia in the 1990s of the last century are almost unavailable, and those data that are available should be observed very carefully and not be taken for granted. Namely, the first data on the amounts of waste generated were recorded in the environmental reports in the Republic of Croatia, prepared in accordance with the Environmental Protection Act *(OG No. 82/94)*, which was developed by the State Administration for Nature Protection and the Environment. Such a system was based on the use of currently valid environmental data and therefore required the introduction of an information system on reporting about environmental protection. These first reports have been aligned with the international matrix of indicators and environment reporting framework to facilitate and accelerate the international exchange of information and their exchange within the Republic of Croatia. Given that they relied on the then discrepant databases, the first environmental analyzes were not complete and harmonised, and they indicated disagreements between indicators as well as lack of some data types.

Within the frame of the analysis of general environmental pressures, these reports analyzed, among other things, the state of the environment

from the point of view of communal and technological waste, which was the term then used to denote production waste. Of course, at that time, there were no data on the annual quantities of generated waste so at the beginning the amounts of the generated communal waste could only be estimated. This pointed to the need to determine the actual quantities and types of communal waste generated in the territory of the Republic of Croatia, as contained in the reports that followed. Thus, in the area of waste management in the period from 2005 to 2008, numerous activities and measures have been launched and implemented which have contributed to the gradual approximation of the given strategic objectives of waste management in the Republic of Croatia. According to the data of the Environment state report of the Republic of Croatia *(Agency for Environmental Protection, 2012)* in the last decade of the 20th century, the amount of communal waste ranged from 979,000 tonnes (1995) to 1,788,000 tonnes (2008). At that time, communal waste also meant waste from construction (solid, earth and mixed waste from the construction sites), which certainly contained some of the asbestos-contaminated waste, but it was not taken into account and there are no data on that.

Although there is no mention of the asbestos-containing waste in the Waste Act *(OG No. 34/95)* from 1995, the implementing document of that law, i.e. the Ordinance on Waste Types from 1996 *(OG No. 27/96)*, first refers to this type of waste in the Waste Catalog, which was an integral part of the Ordinance. Namely, in that catalog there is a list of activities in which waste is generated under number 16 00 00 - Waste not specified elsewhere in the catalog and 17 00 00 - Construction waste and scrap from destruction of objects (including road construction waste). Furthermore, this Catalog, for the first time, includes the asbestos containing waste under separate waste code: 16 02 04 - Old equipment containing free asbestos and 17 01 05 - Asbestos-based building materials.

Regardless of the fact that in 1996, when asbestos-containing wastes were already clearly separated from communal waste and similar waste from industrial and craft plants, some of them, such as wavy roof tiles, plumbing concrete-asbestos pipes, etc. (waste code 17 01 05), were deposited as part of communal waste or they ended up at "wild" landfills in nature or, at best case, on untreated landfills within the factory grounds, Figures 4 *(EBROD, 2017)* and 5 *(Sofilić, 2008)*.

Figure 4. Wild waste landfill with asbestos (waste wave panels) - Donja Vrba near Slavonski Brod

Slika 4. Divlje odlagalište građevinskog otpada koji sadrži azbest (otpadne valovite ploče) – Donja Vrba u blizini Slavonskog Broda

Figure 5. Uncontrolled disposal of asbestos containing waste (waste wave panels) at the unregulated landfill within the factory grounds of Željezara Sisak (Sisak Steelworks)

Slika 5. Nekontrolirano odlaganje otpada koji sadrži azbest (otpadne valovite ploče) na neuređenom odlagalištu unutar tvorničkog kruga Željezare Sisak

In the period from 1995 to 2007 there was no systematic monitoring of the communal waste composition, and the process of determining the composition was carried out only by a small number of cities and municipalities, as there was no recommended methodology for determining

the composition of communal waste. Therefore, it is not surprising that at that time, and even later, some types of waste, which by definition can be part of communal waste, were denoted with waste code from other groups, for a clearer view of the composition of waste, and thus shown in the reports. For example, waste from construction and demolition of houses was recorded under waste code group 17 00 00, which includes waste codes for asbestos containing waste.

Given the fact that the prohibition of use, production, and transport of asbestos products came in force in the Republic of Croatia at the beginning of 2006, in the Report on communal waste for that year *(Agency for Environmental Protection, 2007)*, the waste from group 17 00 00 was shown in the table below as a type of waste that may be part of communal waste. However, for the sake of clarity, it was not classified under the group 20 00 00 and it was referred to as 17 06 05* - asbestos-containing building material, 17 01 07 – mixed waste consisting of concrete, bricks, roof tiles/tiles, and ceramics and 17 09 04 - mixed building waste and waste from demolition.

Although the Waste Act *(OG No. 178/04, 111/06)* from 2004 does not classify asbestos-containing waste into special categories of waste, a separate Ordinance on the Method and Procedures of Management of Asbestos Containing Waste was adopted in 2007 *(OG No. 42/07)*, since management of this type waste, regardless of the lack of relevant legislation, required greater attention. This Ordinance, as well as its new version from 2016, lays down the manner and procedures for the prevention of environment pollution with asbestos and the methods and procedures for the management of asbestos waste and asbestos-containing waste. Adoption of this Ordinance was necessary at the time when the Republic of Croatia was preparing to join the EU, and especially since the EU already adopted Council Directive 87/217/EEC on the prevention and reduction of environmental pollution by asbestos in 1987 *(Council Directive 87/217/EEC, 1987)*, which had a goal to determine the measures and complete the provisions of Directive 83/477/EEC which were already in force.

At that time, the ban on the use, production and transport of asbestos products was already in force in the Republic of Croatia and the Ordinance on the Manner and Methods of Waste Management Containing Asbestos had the task to determine the measures to prevent and reduce asbestos contamination, to establish a management system for asbestos-containing waste, all with the aim of protecting human health and the environment.

The results of the collection of asbestos-containing waste in the period 2008-2018

In July 2008, the Ministry of Environmental Protection, Physical Planning and Construction issued the Instruction for Waste Treatment Containing Asbestos *(OG No. 89/08)* prescribing the conditions to be met when disposing of asbestos waste, which are still in force. Towards the end of 2008, a system for collecting, transporting and disposing of asbestos-containing waste was established in Croatia and citizens have been able to dispose of asbestos waste through authorized collectors since then. These procedures and other conditions for disposal of this waste were prescribed later in the Ordinance on the Methods and Conditions for Waste Disposal, Categories and Work Conditions for Waste Landfills in 2015 *(OG No. 114/15)*.

The first results on the effects of asbestos-containing waste management are presented in the Report on the State of the environment in the Republic of Croatia for the period 2005-2008 *(Agency for Environmental Protection, 2012)* including information on 14 companies licensed to collect this type of waste, which collected 300 tonnes of construction waste containing asbestos in the first year and disposed of it on pre-defined locations. The same report also mentioned the first volumes of asbestos-containing construction waste exported to Germany (14 tonnes).

Hazardous waste containing asbestos was first given due attention in the Act on Sustainable Waste Management *(OG No. 94/13, 73/17, 14/19)* where this waste is classified into specific categories of waste. Among the asbestos-containing products, which become waste after their lifetime expires, there are usually asbestos-cement products or asbestos cement, asbestos friction products, asbestos filters, asbestos textiles, asbestos paper and cardboard, asbestos clutches, asbestos

packaging materials, asbestos materials for reinforcement, asbestos floor coverings, asbestos fillers and the like. All products containing asbestos, declared as waste, are classified into two main groups: a) tightly bound asbestos waste and b) weakly bound asbestos waste, as defined in the Ordinance on the Management of Construction Waste and Asbestos-Containing Waste in 2016 *(OG No. 69/16)*.

Today, the Waste catalog identified in the Ordinance on Waste Catalogue *(OG No. 90/15)*, prepared in line with the European List of Waste, has been used for the identification of waste generated, which is determined by waste category. Accordingly, hazardous waste is considered a waste which, if inhaled or ingested or if it penetrates the skin, can cause a limited risk to health *("hazardous")* or if it is inhaled or ingested or if it penetrates the skin it can cause cancer or increase its occurrence *("carcinogenic").* Therefore, knowing its harmfulness effects, asbestos-containing waste is classified into hazardous waste and has an asterisk next to the waste code (*). Accordingly, the waste containing asbestos is included in the current Waste Catalog in subgroup 17 06 - Insulation materials and construction materials containing asbestos entered under waste code 17 06 01 * - Insulating materials containing asbestos and 17 06 05 * - Construction materials containing asbestos.

In recent years, efforts have been made to align relevant legislation, as well as the implementation of prescribed measures for effective management of asbestos-containing waste. Consequently, a system of management of this type of waste has been developed - starting with the definition and construction of special landfills/cassettes for the disposal of construction waste containing asbestos as well as the defining of authorized collectors. Disposal of waste containing asbestos on these specially prepared plates/cassettes began in mid-2011 with completion of the construction of a total of 17 cassettes with a total capacity of 126,560 tonnes, Figure 6.

Figure 6. Landfill sites/cassettes in the Republic of Croatia for disposal of asbestos-containing construction waste

Slika 6. Lokacije odlagališnih ploha/kazeta u Republici Hrvatskoj za zbrinjavanje građevnog otpada koji sadrži azbest

The Croatian Agency for Environment and Nature is obliged to report to the public on asbestos waste management results, and asbestos-related waste management obligations are set out in the Act on Sustainable Waste Management *(OG No. 94/13, 73/17, 14/19)* and in the Ordinance on the Management of Construction Waste and Asbestos-Containing Waste *(OG No. 69/16)*.

In preparing a report on asbestos-containing construction waste for the observed period, the data from Environmental Protection and Energy Efficiency Fund, as well as the Croatian Agency for Environment and Nature data from the Environmental Pollution Register are commonly used. The report contains an overview of data on the collected and disposed amounts of asbestos-containing construction waste collected on applications forms received from companies that have signed a contract with Environmental Protection and Energy Efficiency Fund. At the same time, the report provides an overview of the capacities of the individual surfaces/cassettes to which this wa-

ste is disposed of and the data on the volumes of this waste reported to the Environmental Pollution Register base by all companies licensed to treat asbestos-containing waste. Furthermore, it shows data on volumes of exported asbestos-containing contruction waste for the observed period.

Based on the data published by the Environmental Protection and Energy Efficiency Fund and Croatian Agency for Environment and Nature *(Croatian Agency for Environment and Nature 2016, 2018, 2019, Ministry of Environment and Energy, 2019, Agency for Environmental Protection, 2012, 2013, 2014, 2016, 2016)*, the volumes of construction waste containing asbestos collected from 2008 to 2017 ranged from 0.004 tonnes (2008) to 11,673 tonnes (2013), representing shares in total collected waste from <0.01% (2008) to 1.34% (2013), Table 5 *(Agency for Environmental Protection, 2012, Croatian Agency for Environment and Nature 2018, 2019, Ministry of Environment and Energy, 2019, Agency for Environmental Protection, 2012, 2013, 2014, 2016, 2016)*.

Table 5. Collected, deposited, and exported quantities of construction waste (17 01 01, 17 01 02, 17 01 03, 17 01 07, 17 03 02, 17 06 04, 17 08 02 and 17 09 04) and asbestos-containing construction waste (17 06 05 *) in the period 2008-2018

Tablica 5. Sakupljene, odložene i izvezene količine građevnog otpada (17 01 01, 17 01 02, 17 01 03, 17 01 07, 17 03 02, 17 06 04, 17 08 02 i 17 09 04) i građevnog otpada koji sadrži azbest (17 06 05*) u razdoblju 2008.-2018.

Waste	Year										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Construction waste (t)	194,406	131,863	362,567	579,240	717,382	872,782	761,312	882,256	1,207,156	1,225,263	1,243,642
Construction waste containing asbestos (t)	0,004	1,660	3,283	3,637	8,985	11,673	9,284	9,477	6,219	1,605	2,823
Share of asbestos-containing construction waste in construction waste (%)	<0,01	1,26	0,9	0,6	1,25	1,34	1,22	1,07	0,52	0,13	0,26
Deposited asbestos-containing construction waste (t)	-	-	-	5,004	10,335	11,237	10,192	10,765	4,371	1,990	2,827
Exported asbestos-containing construction waste (t)	14	ND	ND	2,350	2,034	136	134	278	154	ND	236

ND - no data

In the context of asbestos-containing waste, with the exception of construction material waste containing asbestos, the waste that belongs to the same subgroup 17 06 - insulation materials and construction materials containing asbestos is collected separately, and has waste code 17 06 01* - and refers to the insulating materials containing asbestos.

The Environmental Protection Agency first showed the results of asbestos waste management for 2011, for each waste code in particular (17 06 01 * and 17 06 05 *), whereas in the reports for the previous year this waste was likely to be presented within the total amount of hazardous and non-hazardous waste generated within the group 17 00 00.

The data in the Environmental Protection Agency's annual report on the Environmental Pollution Register have shown that the quantities of waste with waste code 17 06 01 * - asbestos-containing insulating materials ranged from 0.77 tonnes (2011) to 86.54 tonnes (2015).

CONCLUSION

Over the past ten years, the Republic of Croatia has been developing a management system for waste - starting from the site locations and the construction of special landfills/cassettes for the disposal of asbestos-containing construction waste as well as the issuance of authorizations to legal entities for collecting this type of waste.

Like any other system, based on the results and performance of its application, this asbestos-containing waste management system needs certain improvements, no matter how successful it now may seem.

The efficiency of this system is best reflected in periodic overviews of asbestos-containing waste for a given period, using the Environmental Protection and Energy Efficiency Fund data, as well as the Croatian Agency for Environment and Nature data collected through Environmental Pollution Register and Database of Cross-Border Waste Transport. These surveys contain data on collected and disposed volumes of asbestos-containing waste, an overview of the capacity of the individual landfills/cassettes where it is disposed of, as well as the data on the volumes of this type of waste reported to the Environmental Pollution Register base by all companies that have a license for asbestos-containing waste processing.

Based on data collected in the period 2008 to 2018, the quantities of collected construction waste containing asbestos ranged from 0.004 tonnes (2008) to 11.673 tonnes (2013), representing the shares in total collected construction waste of <0.01% (2008) to 1.34% (2013). Compared to the previous years when the volumes of collected and disposed asbestos-containing construction waste were significant, in 2017 this amount was only 1.990 tonnes. The main reason for this is the fact that Environmental Protection and Energy Efficiency Fund provides no co-financing system that would encourage collecting this type of waste.

From all the data presented, it can be concluded that in the observed period, authorized collectors, who signed the contract with the Environmental Protection and Energy Efficiency Fund, collected a total of 58,650 tonnes of asbestos- containing construction waste, out of which a total of 56,721 tonnes were deposited on specially built landfills/cassettes, whereas at the same period about 5,336 tonnes of waste was exported.

However, it is important to emphasize that in the Republic of Croatia there are still identified and unidentified (wild) landfills for construction waste containing asbestos (Vranjic, Solin), which then pose a danger in interaction with atmospheric conditions. It is extremely important to locate and remediate such landfills of construction waste containing asbestos, which is not properly disposed of.

Given all the above and given that there are still inconsistencies between the data on the reported volumes of construction waste, including the asbestos-containing portion of it, with economic and other indicators for the construction sector, there is a need to improve the flow monitoring system for this special category of waste, in order to remove as much asbestos as possible from the environment - at least the one we see on our roofs.

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ISKUSTVA U GOSPODARENJU OTPADOM KOJI SADRŽI AZBEST U REPUBLICI HRVATSKOJ

SAŽETAK: U radu je dan pregled podataka o proizvodnji azbesta u svijetu i Republici Hrvatskoj u razdoblju od 2000. do 2017. godine te njegovoj potrošnji, od 1995. do 2010. godine. Analizirani su rezultati sakupljanja otpada koji sadrži azbest od 1995. do 2018. godine i opisana su iskustva Republike Hrvatske u gospodarenju otpadom koji sadrži azbest u skladu s važećom nacionalnom legislativom. Iako azbest ne predstavlja rizik sve dok se njegovi proizvodi ne oštete prilikom loma, tijekom transporta ili raspadanja, on predstavlja potencijalnu opasnost za ljudsko zdravlje. Danas u svijetu svakih pet minuta netko umre od bolesti povezane s azbestom, poput azbestoze i karcinoma uzrokovanog azbestom. Iz ovih razloga je većina država u svijetu još 1999. godine prihvatila obvezu izvršenja niza mjera za prestanak uporabe azbesta, dok se istovremeno u Republiku Hrvatsku još uvijek uvozilo oko 4000 tona azbesta na godinu. Republika Hrvatska je tek 2006. godine zabranila proizvodnju, promet i upotrebu azbesta, a predmeti od azbesta kojima je vijek trajanja istekao, završavali su u komunalnom otpadu, zbog čega se nametnula potreba za donošenjem posebnih propisa kojima je uređeno gospodarenje otpadom koji sadrži azbest. U proteklih desetak godina u Republici Hrvatskoj je razvijan sustav gospodarenja otpadom koji sadrži azbest. Bez obzira na uspješnost njegove primjene, nužna su određena poboljšanja, jer se podaci o količinama prijavljenog nastalog građevnog otpada, a s time i onog dijela koji sadrži azbest, ne podudaraju s gospodarskim i drugim pokazateljima za građevni sektor.

Ključne riječi: *azbest, zdravstveni rizik, gospodarenje otpadom, zakonski propisi*

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