

# Chapter 1

## Potentially Toxic Construction Materials: An Introduction



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**Abstract** For the development of a nation, building materials are important. After the Industrial Revolution in the early nineteenth century, more building activities were generated with the production of construction materials to enhance economic development and jobs. Thousands of synthetic construction materials have been developed and produced worldwide. They come in various shapes, sizes and amounts that serve various forms and functions. Toxic chemicals may be found in common construction goods, such as solvents, paints and varnishes, or dust from building materials. But in the modern era, large numbers of toxic construction materials are being used for construction, a purpose which later gets released in the surroundings, polluting air, water and soil. These toxins are responsible for causing a lot of health issues such as asthma, burning eyes itchininess, inflammation of the nose and throat, headache, skin irritations or rashes, dizziness, fatigue, reproductive dysfunction, nausea, endocrine system disruption, impairment of infant growth and birth defects, suppression of the immune system and cancer. It is not possible to see or smell any of these products, but they are able to cause damage. They can emit low-level toxic exposure or produce cancer-causing carcinogenic substances. The effects may cause short-term effects that can cause death, such as skin allergies or long-lasting health effects.

**Keywords** Asbestos · Building materials · Health issues · Phthalates · Toxic

### 1.1 Introduction

Today the world faces a number of major challenges that may lead to the end of our society if it is not solved, or if it is just postponed. One of the major challenges is the consumption of many forms of energy, including non-renewable ones used by humans, releasing a certain amount of waste in the consumption process, and a large

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amount of waste products in the surrounding environment making our planet worse (Meadows et al. 1972). The immediate effects of consuming practices of societies, with impacts for environments and future centuries, have not yet been thoroughly articulated in intergenerational and inter-geographical dimensions (Stern et al. 2006).

In order to achieve sustainable and ecofriendly construction, the European Union has provided guidelines regarding the use of raw materials and production of construction wastes. According to these guidelines, the raw material consumption should not exceed 30% and the waste production by 40%. Not only the use of sustainable raw materials is essential for construction purposes but also the production of toxic wastes is equally significant. The people in the early centuries used to construct buildings made of raw materials that do not release any toxic product to the environment. However, in today's world, a vast amount of hazardous building materials are used for construction, which are then emitted into the environment, polluting the air, water, and soil. Asthma, burning eyes, itchiness, itching of the nose and mouth, nausea, itchy skin or rashes, lightheadedness, weakness, reproductive dysfunction, fatigue, endocrine system dysfunction, deficiency of child development and congenital abnormalities, neuroinflammation, and cancer are all caused by these toxins. In addition to the toxicity of indoor building materials, the potential for toxicity during the processing of such chemicals must not be ignored. For example, Bhopal disaster in India in 1984, in which nearly 15,000 deaths and health problems were caused by a cloud of methyl isocyanide in almost 200,000 human beings (Varma and Mulay 2006; Satyanand 2008). Hazardous waste is produced during the manufacture of chemical materials and that impact must be connected to building materials containing these chemicals. There are a lot of hazardous chemicals used in the construction industry, and some of them are explored in this chapter.

## 1.2 Polyvinyl Chloride (PVC)

Any material or substance consisting of PVC composition, i.e. mixture of a vinyl chloride polymer or copolymer with different additives, is PVC or polyvinyl chloride (Titow 2012). The only important plastic used in buildings that contain chlorine is PVC. Most of the chemicals, especially polyvinyl chloride utilized during manufacturing and installation of construction materials possess significant toxicity, thus come under severe examination. Vinyl 3 which is another name for Polyvinyl chloride (PVC) is one of the extensively used chlorine-containing plastic polymers in the United States with about 14 billion pounds manufactured in the U.S each year (Sass et al. 2005). More than 75% of PVC use is accounted by the construction industry (Jebens et al. 2013). PVC is used in the building sector for window frames, doors, roller shutters, drinking pressure tubing, wall covering, reservoir lining, fencing, etc. (Patrick 2005). The plastic industry uses a group of chemicals to make PVCs flexible and functional, the majority of which pose concerns about human health and the environment. Throughout the lifecycle of PVC and other chlorinated plastics, the chlorine content has the ability to generate dioxins through processing and

disposal (Thornton 2002). PVCs act as a source of Dioxins which are known for their bioaccumulative potential, thus making them a global concern.

Dioxins are inevitable chemicals produced during the production, burning and removal of chlorine-containing materials. Dioxins are one of the most well-known carcinogens in humans (Karstensen 2008). These are the chemical wastes produced during the industrial process of chlorine emerging industries as are produced during the manufacture of PVCs. Since dioxins and other chemicals like furans are very toxic and bio-cumulative; contaminate all food chains, resulting in hazardous effects on biodiversity (Tillitt et al. 1993). In the last four centuries, according to Thornton (2000), the concentration of both dioxin and furans rose from zero to almost 100% in two German lakes and the Baltic region. In addition, in the northern Pacific Ocean, chemical analysis of dolphins showed dioxin and furan levels between 13 and 37 million times more than in surrounding water (Thorton 2002). Several groups of scientists have already proposed that industrial processing of chlorine should be banned (Flores et al. 2018). In fact, dioxins belong to one of only 12 chemicals or families of chemicals targeted for removal by “The Stockholm Convention on Persistent Organic Pollutants (POPs), which is an international treaty. Some of the dioxins are not only strong carcinogens, but also behave as reproductive and growth toxicants. Many of them affect the endocrine and immune systems badly.

### 1.3 Phthalates

In PVC plastics, phthalates are used as plasticizers. Since phthalate plasticizers are not chemically bound to PVC, they are able to leach, migrate or evaporate into the atmosphere and indoor air, food, other products, etc. (Schindler and Hauser 2004). In health care environments, phthalates are also present in PVC plastic which became another source of exposure to this substance. Inherently rigid, PVC includes additives due to which it became flexible, therefore can be used in bags, flooring wall coverings, upholstery and shower curtains. Established reproductive and developmental toxicants are certain phthalates used for softening PVC. Phthalates cannot bind with PVC, therefore they are released into the environment e.g., into air, water and soil, causing many respiratory problems in adults and children, such as pneumoconiosis, rhinitis, asthma and both insulin resistance and obesity in adults. In the United States, PVC processing uses a large percentage of phthalates and risk evaluations have been performed on phthalates through numerous expert panels in both America and Europe (Heudorf et al. 2007).

## 1.4 Organic Compounds

### 1.4.1 Volatile Organic Compounds (VOCs)

The carbon-containing compounds that have the ability to vaporize at room temperature are known as Volatile Organic Compounds (VOCs). Therefore, these compounds can evaporate eventually from a construction product into the air which becomes a source of inhalation to human beings. Chemicals of VOC-type are utilized during the processing of certain plastics and for items such as structural wood or insulators for preparation of binders and other resins; also increase stain repellent and water resistance when used in paints, adhesives, coatings and other treatments (Brown et al. 1994). Formaldehyde, toluene, isocyanates, acetaldehyde, benzene and xylene are some common troublesome VOC compounds released from building materials. When a product is first mounted, VOCs are released in large amounts and then over time in lower amounts, connected to the amount of moisture present in items that are wet at the beginning and then eventually dry. Solid materials such as fabrics, furniture, flooring and furnishings release VOCs more steadily and for a longer period of time, therefore, retaining a low level of emissions. When exposed, construction materials coated in plastic at the point of production and uncovered at the development site or construction site will release concentrated VOCs. Most of these VOCs have significant health implications as well. Some of the VOCs are responsible for causing signs of temporary acute sick construction syndrome and other long-lasting serious health implications, like liver, nervous system and kidney damage, and also increase the risk of cancer (Salasar 2007). Formaldehyde, a recognized human carcinogen, is one of the VOCs of major concern. The possible ecological and health impacts of formaldehyde have generated such a high alarm that many foreign and other national bodies have placed bans on the use of products where formaldehyde can usually be found and discharged (Hileman 1984). Several countries, including Japan, Germany, Netherlands, Norway and Finland have already taken measures to limit the emissions of formaldehyde in textiles. Other VOCs, like xylene, benzene, toluene, and acetaldehyde also pose health and ecological issues, in addition to those caused by formaldehyde. In certain processes e.g., composite wood formation, fabric manufacturing and batt insulation, formaldehyde is used as a binder to prevent shrinkage of the fabric, for improving crease-resistance, for providing stability to dimensions and improving color quality. It is also utilized to increase stain resistance as a part of certain finishing treatments (Schindler and Hauser 2004).

### 1.4.2 Semi-volatile Organic Compounds (SVOCs)

Organic compounds with higher vapor pressures and released as gas more slowly than VOCs from materials containing them are known as semi-volatile compounds. These compounds have more possibility to be transferred to humans through touch or

by binding to dust or through ingestion (Lucattini et al. 2018). In building materials, semi-volatile organic compounds are used for many benefits like enhanced flexibility, protection from water and stains. Halogenated flame retardants prevent combustion or flame propagation. In comparison to VOCs, which appear to be released quickly in the first few hours or days after a product is installed and then emit slowly with time, products possessing SVOCs release them more gradually and over longer periods of time. A variety of chemicals used in construction materials are showing up in higher amounts in human milk, tissue samples, and blood, raising fears about their increasing ability to cause cancer or other significant health effects (Rumchev et al. 2007). Certain VOCs have also been discovered in household dust emitted from construction materials into the atmosphere (Xu and Little 2006). The possible risk of exposure to such dust compounds can be equal to or greater than that of food intake exposure in infants and adults (Hwang et al. 2008). While several SVOCs occur in construction materials, phthalates (softeners used in plastic PVC), halogenated flame retardants (chemicals applied to inhibition products) and perfluorochemicals (added to stain resistance or water repellency products) are of particular concern.

## 1.5 Heavy Metals

### 1.5.1 *Asbestos*

Asbestos can be found in building materials such as walls, floors, and ceilings. Asbestos contains different fibers with a length of 5 mm and a diameter of 3 mm. The various fibers present in asbestos include crocidolite, chrysotile, anthophyllite, amosite, actinolite and tremolite. Until 1960, the effects of asbestos on health were not recognized in the scientific world and these problems were not taken seriously up to 1980. Therefore, most of the building structures formed between 1920s to late 1980s contain mostly asbestos. Since 1980 the scientific world recognizes the ill effects of asbestos and its problems, due to which it was taken seriously.

Asbestos is of different types like white, brown and blue asbestos. White asbestos mostly consists of chrysotile fibers while brown and blue consist of amosite and crocidolite fibers respectively. Among them, blue and brown are highly toxic whereas white asbestos is nontoxic. Blue and brown asbestos is responsible for causing pleural mesothelioma in which patients die after 12 months of exposure (Bianchi et al. 1997; Jarvholm et al. 1999; Azuma et al. 2009). Other health hazards associated with asbestos include serious health issues like asbestosis (a disease in which there is the accumulation of acid which leads to lung damage. This acid is mainly produced in the body to dissolve the fibers of asbestos), lung cancer and other types of cancers. Asbestos is highly toxic even a little exposure to its small quantity can lead to various types of diseases.

### ***1.5.2 Lead***

Lead has a very important role in construction. Lead is considered to be an important component of roofs, tank lining and electrical gadgets used in construction. Since ancient times lead has been used in water pipes due to its less corrosive properties (Hodge 1981; Dutrizac et al. 1982; Nriagu 1983). But some quantity of corrosiveness fatal to health still is presented in lead. Various authors are of the view that the use of lead in tank linings and water pipes can lead to corrosion which can be washed away by water with due course of time, hence can lead to water contamination (Zietz et al. 2009). So lead contaminated water is very fatal to human beings. It can cause damage to the central nervous system, kidneys, cardiovascular system and reproductive system. Lead is very poisonous as it directly enters into the bloodstream causes calcium simulation which enables it to cross the brain and blood barrier in children and infants. It causes behavioral problems (Pocock et al. 1994; Canfield et al. 2003; Wilhelm and Dieter 2003). Troesken (2006) is of the view that during the past two centuries the use of lead used in plumbing is as huge as the Bhopal disaster issue to which thousands of children in the USA have lost their lives.

### ***1.5.3 Cadmium***

Cadmium is an insoluble metal that is resistant to corrosion. Hence this metal is used to coat steel and iron to protect them from corrosion. The compounds of cadmium are also used for plastic stabilization and glass coloring as these are available in various colors including red, orange, and yellow pigments. This chemical is also used in alloys, solar cells and electroplating. Cadmium and its compounds are highly toxic and can cause cancer and other body problems including cardiovascular, neurological, respiratory and renal by causing damage to the heart, brain, lungs and kidney (Hayat et al. 2019).

### ***1.5.4 Mercury***

Mercury is considered to be one of the most influential neurotoxins causing damage to the brain particularly in fetuses and children (Trasande et al. 2005). Therefore, the use of mercury in building materials has been discouraged for the past many years. But in most construction materials mercury is still being used.

### ***1.5.5 Silica***

Silica is commonly found in stones, clay, sand, tiles, concrete and bricks. Therefore, is considered to be an important component in building materials. e.g. granite contains almost 15–30% of silica whereas the quantity of silica in sandstone is greater than 70%. Silica is considered to cause a high risk of lung diseases in construction workers after asbestos, as it is inhaled directly after construction or after grinding, cutting, or blasting stones. Long exposure to silica can lead to cancer and many respiratory tract diseases. In causing carcinomas it ranks as one of the high and influential elements (Hoy and Chambers 2020).

## **1.6 Other Sources of Toxic Materials**

### ***1.6.1 Wood Treatment Chemicals***

Wood is an important building material for construction purposes but at the same time, it is most vulnerable to fungus and insects (Morrell 2002). Therefore various treatments are used to preserve the wooden materials. For this number of chemicals are used that are water-soluble e.g., creosotes (includes wood tar creosote, coal tar creosote and oil tar creosote), arsenic, copper and chrome. These chemicals are very toxic and are responsible for contaminating the environment. Creosote contains cancer-causing agents (ATSDR 2002; Smith 2008) therefore its use for wood preservation is banned. Creosote is also used for the construction of cross ties in railways. As it is the most toxic element, its use must be minimized and can no longer be reused (Pruszinski 1999). In addition to creosote, arsenic can also be used to prevent the wood from insect attacks. These chemicals cause a lot of health issues including abdominal pain, vomiting, diarrhea, heart diseases, thickening of the skin and even cancer. In addition to arsenic pentachlorophenol, another wood preservative, can cause kidney and liver damage.

### ***1.6.2 Bisphenol A***

Bisphenol A (BPA) is an organic synthetic compound with two hydroxyphenyl groups that belong to the diphenylmethane variants and bisphenols groups. This chemical is used in building materials to produce plastic polymers and surface coatings, mostly polycarbonates and epoxy resins. BPA also serves as the basic material to be used in making epoxy coatings of paint, adhesive and many other products. The composition of epoxy products cannot be easily understood, nonetheless, epoxy resins have mostly 2 chemicals used in their manufacture first is BPA and the second one is epichlorohydrin.

There are many health hazards related to bisphenol A, the most common health hazards are related to male and female fertility, hormonal imbalance including polycystic ovarian syndrome (PCOS), carcinomas of breast and prostate glands. Therefore users are at high risk of BPA. Hence their use in construction materials should be minimized. A study was carried out in Japan in which it was found that exposure to epoxy resins can lead to hormonal imbalance in male workers. Epoxy resins on entering into the human body can lead to many health-related issues (Hanaoka et al. 2002).

The use of BPA in the manufacture of polycarbonate plastics should be minimized as it can leach from the bottles and can liners formed from polycarbonate plastics which can become one of the main reasons for endocrine imbalance (Rubin 2011).

### ***1.6.3 Materials Releasing Toxic Fumes on Fire***

There are some materials used in building materials that release toxic fumes when these materials catch fire. Large numbers of deaths during fires are caused due to inhalation of these materials. There is an increase in such incidents since 1980 due to the large usage of these materials in buildings from the past couple of years (Gann et al. 1994; Hall and Harwood 1995; Wu 2001; Levin and Kuligowski 2005). Some of the elements have a very high toxic index. Elements like polyethylene and polyurethane foam have a toxicity index greater than 10 (Liang and Ho 2007), so there is a greater recommendation not to use these elements because of their highly toxic nature. Therefore these materials should be covered by non-combustible substances (Liang and Ho 2007). Another material polystyrene is highly combustible and releases very large toxic fumes, therefore their use should be avoided.

There is an initiative for the usage of a large number of flame retardants, which are the chemicals that are used in construction materials to control the spread of flames. But these retardants also release toxic chemicals upon degradation in gaseous forms, which can easily be inhaled. Upon inhalation of these elements, a number of hormonal imbalances can occur in humans especially in children.

### ***1.6.4 Formaldehyde***

Formaldehyde is a colorless gas. It is used in many construction materials as binders or adhesives in various woods and carpet products. It is responsible for causing a number of respiratory problems and dermatitis (Kim et al. 2011).



### 1.6.5 Fiberglass

Fiberglass is used for roofing and as an insulator of heat. Exposure to this material causes skin irritation, bronchitis and asthma to workers on inhalation after cutting, chopping and trimming of these fibers (Neghab and Alipour 2009).

## 1.7 Conclusion

Most of the substances used in construction materials possess certain degree of toxicity. These toxic substances are released at the stage of their production, during fires and after an installation of the project. These substances have a negative impact on both humans and the surrounding environment. Most of the health issues like cancer, kidney damage, cardiac arrests are associated with these substances. Therefore, there is a dire need to utilize sustainable materials instead of such toxic materials. In addition to this, legal regulations and education to the common masses can help a lot.

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