The Domestic Chemical Cocktail

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Summary

There is compelling evidence that toxicity in a very large number of ubiquitous building materials is a contributory trigger to people with asthma and allergies. An estimated 55,000 materials are available to the building industry, of which only 3% have been tested for their toxicity on humans. In the UK, identification of single toxic materials, within a more complex cocktail of products and materials, and proof of their contribution to a hostile indoor climate, is difficult to determine.

This paper has been written from the perspective of a practising architect seeking to design healthy buildings. It aims to outline the main issues surrounding chemical toxicity in the built environment highlighting the principal sources of toxicity and detailing alternative materials and solutions.

Keywords

Chemical Sensitivity, Toxic Materials, Benign Construction, indoor air quality, healthy housing

Introduction

"In 1971 the state laboratory for the control and inspection of foodstuffs in Geneva was given a new, state of the art building with all the latest in sophisticated technical installations. After occupation all the food tests started to register excessive toxicity levels. When control measures were made back in the previous building the toxicity levels were found to be 'back to normal'. Ultimately it was discovered that the 'high-tech' materials in the new building were the cause of the high toxicity levels in the foodstuffs, and that it was occurring after only a short storage time in the building. Toxic emissions were found to be leaking from paints, plastic materials, varnishes, flooring and furniture and were poisoning both the room air and the foodstuffs waiting to be tested." (Hubert Pham translated from German by H Liddell 1971)

Awareness and management of chemical toxicity in built development is, at least in principle, now recognized as good practice in terms of site health and safety, but we are still a long way from establishing toxicity as a life-cycle concern that embraces manufacture to end-of-life, and beyond. This is despite a substantial body of evidence to indicate that many construction materials are potentially hazardous to health and deleterious to the environment throughout their life cycle.

The design of buildings that do not impose a toxic load on constructors, users or the environment is a crucial aspect of policy implementation if we are to meet our commitments to enhance well-being, health and biodiversity. In regulatory terms this is a relatively new area but there are recent studies that include extensive referencing in respect of policy and legislation[12].

Illustration 1: Rauli Kindergarten, Norway

Rauli Kindergarten (2005) by Gaia Lista was designed with 100% benign materials in the indoor climate.
Photo source: B Berge

The basis of this paper is merely a presumption for chemical avoidance rather than a scientific analysis. It aims to enable those who wish to err on the side of caution to do so.

The paper highlights the following issues: -

- The current state of the building materials supply industry
- Labelling and the supply chain of building materials;
- The nature and extent of the problem for architects and specifiers, in terms of health and safety and duty of care;
- Identification of the key problems with regard to toxicity in buildings and suggestions for dealing with them;

Some studies have implicated building materials including PVC, some paints, varnishes, insulation materials, timber treatments and wood composites; many furnishings are also implicated[3]. There is increasing evidence of the role that toxicology plays in pre-disposing people to asthma. Evidence is appearing that particulates of elements such as cobalt, nickel, cadmium and mercury have a profound effect on the immune system[45]. The US Timber industry agreed to phase out use of Copper Chrome Arsenate (CCA) timber treatment, which has been a source of concern, provided that by agreeing to do so they were immune from retrospective prosecution[6].

There is growing concern about poor indoor air quality and other adverse factors within buildings, highlighted by 'Building Related Illness'. Indoor air quality is now legislated for in many countries[7]. This guide limits its remit to construction and fixtures, but not the ventilation, fit-out, furnishings and finishes that are also implicated. They are highly likely to contain toxic materials and have cleaning and decoration regimes that use materials that are potentially chemically hazardous. There can also be a risk that inappropriate construction can lead to biological toxicity, for example, through mould growth. Whilst this study is focussing on chemical toxicity the authors feel that it would be an artificial boundary not to refer to this significant risk. Designers and specifiers should discuss these issues with clients and users.

Justification

"Most testing of chemical toxicity is undertaken on the basis of exposure at work by adults. We are ignorant of the effects on children and other species which might be vital to the ecological make-up of the planet. No one knows the cocktail effect. It is permitted only because the victims are anonymous."
Steingraber in Living Downstream (1998)[8]

Ideally buildings should contain no materials that could be health damaging. Also building materials and finishes should not depend on suspect chemical cleaning agents or toxic treatments. The construction should not enable condensation and mould to occur in the indoor environment or interstitially. However it is common knowledge in the profession that most construction activity falls far short of what is readily achievable with only a little care and attention. As a consequence: -

- We are failing to fulfill our policies and obligations regarding environmental protection and enhancement.
- Many toxins originate as rare materials and their dispersal represents a waste of potentially valuable resources.
- We are missing opportunities to reclaim materials that would have real economic and resource benefits.
- We are missing the significant commercial opportunities for manufacturers to develop cleaner products for expanding markets at home and overseas.
- We are moving the economic liabilities for health, mitigation and remediation into the future.

Construction Related Chemical Pollution

At the beginning of the 20th century, about 50 materials were used in buildings. Now, about 55,000 building materials are available, and over half are man-made. There has also been a dramatic upsurge in pollutants in furnishings, fabrics and finishes.

VOCs

Volatile organic compounds are chemicals that are emitted as gases from certain solids or liquids at room temperature. There are 50 – 300 chemicals that can be classed as VOCs in the average indoor environment. The main sources in domestic environments are paint, floor sealant, vinyl and furnishings. VOC levels have been shown to be a lot higher during and after construction This is often apparent in the smell of a new building, or where a new carpet has been fitted. Off gassing of the VOCs from the materials can occur over a prolonged period of time.

Formaldehyde is the most common VOC in indoor air, and is emitted from carpeting, particleboard, furniture and new clothing. It is colourless but has a distinctive odour. Certain VOCs, including formaldehyde, are often absorbed onto surfaces and textiles reducing peak concentrations but prolonging overall exposure. Exposure to VOCs is primarily though inhalation, although some VOCs are ingested through food, or liquids. Exposure to VOCs can result in irritation to the nose, throat and eyes; they can cause headaches, nausea, dizziness, and can aggravate asthma. Chronic health effects linked to VOC exposure include cancer, and damage to the liver, kidney and central nervous system.

Illustration 2: Chipboard Flooring Material

Chipboard is an ubiquitous flooring material. It is usually bonded together with Phenol formaldehyde resin (formaldhyde is one of the most virulent triggers for allergic reactions). In addition it is sometimes treated with preservatives of a type “banned in the USA since 2002”

Photo source: H Liddell

The majority of studies have focussed on occupational exposure, where VOC levels are often higher, and on the impact of one specific chemical over a relatively short period. Little is known about the effect of combined exposure or of the effects of low level long term exposure. It has been repeatedly shown that working as a painter increases the risk of lung cancer by 40% - however, it has not been possible to identify the causative chemical due to mixed exposures[9]. Common VOCs are listed below:

• Formaldehyde	• Benzene	• Toluene
• Methylene	• Chloride	• Xylene
• Ethylene glycol	• Texanol	• ß1,3-butadiene

There is some information connecting the use of plastics in the home and respiratory illness. A Finnish study that investigated the presence of PVC based wall materials in homes and respiratory health of children indicated that there might be adverse health effects on the lower respiratory tracts of small children from emissions from indoor plastics[10]. It also concluded that there was an increased risk of pneumonia in children exposed to plastic wall materials. Many of the water-based paints used in the home still contribute small amounts of VOCs to the indoor environment and have been linked to the exacerbation of asthma systems. As a consequence of medical concerns, as well as the downstream impacts on the wider environment, a number of 'VOC free' paints have appeared on the market in recent years.

Illustration 3: Standard Wood Preservers

Standard wood preservers come with a serious health and environmental warning.

Photo source: H Liddell

Moisture

Changes to construction methods, and material specification has contributed to changed heat and moisture retaining capacities of buildings. As a consequence, fluctuations in moisture content in buildings are greater and so are the problems caused by moisture, which serves as a medium for chemical reactions and microbial growth. Servicing strategies are also a major cause for concern. Modern buildings are less well ventilated than in the past (it is not unusual to find air changes of less than one per hour in modern, well insulated buildings). Whilst this is a trend necessary for environmental and energy benefits, it can lead to a build up of triggers in the air and to excessive moisture levels. Low ventilation rates must be tied inextricably to specification of benign and low emission materials.

Chemically Polluting Materials

Solvents (chemicals commonly used in paints and adhesives) – Risks range from: irritation & headaches to dermatitis, colour blindness, brain damage, cancer and even death.

Possible solvent-free alternatives include;

- natural water-based mineral paint and linseed oil-based gloss paint;
- avoidance of materials containing or requiring glues, e.g. manufactured wood products, wallpaper. Where use of glues is difficult to avoid, (e.g. for installation of linoleum or rubber flooring) solvent & formaldehyde free glues can be used;
- Avoidance of timber treatments through detailing – standard wood preservers come with a serious health and environmental warning.

There are a number of risks associated with PVC through its life cycle;

- During manufacture: ingredients such as the vinyl chloride monomer emit dioxin and other persistent pollutants present both acute and chronic health hazards.
- During use: PVC products can leach toxic additives, for example, flooring can release softeners called phthalates (recognised asthma triggers also linked to genital deformities, premature births, hormone disruption and cancer).
- In disposal: leaches toxic additives when disposed of in landfill; emits dioxin and heavy metals when incinerated.
- In fire: emits hydrogen chloride gas and dioxin.

Possible alternative to PVC include

- Stainless steel conduits;
- PE, PP or rubber sheathing to wiring;
- Copper or PE water pipes;
- PTFE (Polytetrafluoroethylene) non-reactive pipework;
- Cast iron rainwater goods;
- Linoleum or rubber in lieu of vinyl floor coverings.

Formaldehyde is present in significant quantities in a wide range of house furniture, insulation and floor and wall fittings. It is used in hundreds of industrial processes including the manufacture of particle boards, MDF, chipboard and plywood, thermal insulation foams, adhesives, glues and resins. Exposure to high levels or long-term low levels of formaldehyde may cause cancer (emissions still occur after installation).

Lifecycle

Toxicity can be an issue at every stage from the extraction to the disposal of a material or product, and subsequent dispersal in the environment. The recycling and re-use of building products and materials is generally regarded as an environmentally positive activity. However, there is a concern that recycled products and materials might increasingly include a toxic component (e.g., a timber floorboard beneath a polluting industrial activity). There are still no mechanisms in place to vet the toxicity of recycled materials, despite the ratcheting up of requirements for their use. This tendency for quantity issues to precede, and then dominate, over issues of quality places thoughtful designers in a difficult position in relation to some perceived good practice. Guidance on assessing a material's pedigree would be helpful if the changing requirements are to have a genuinely positive result on health and the environment.

Designers need to look to their own future liabilities. Selecting and designing details that minimise chemical load at the outset minimises risks during the project life and also more readily facilitates the materials being a valuable resource at the end of one lifespan. Given that control of environmental pollution is likely to become more stringent, this makes healthy building an increasingly attractive strategy.

Leachates

These are apparent in landfill and arise from a wide range of construction materials and products including concrete, plastics, paper and electrical goods. Heavy metals, such as chromium and stainless steel, used in the construction industry manufacturing process, are a particular concern, as are treatments and finishes that leach from buildings in use. Another area of concern is the final destination of unrecoverable non-biodegradable wastes from building sites, such as plastics and plasticisers that release chemicals which are disruptive to ecosystems over time. The potential adverse impacts on biodiversity are evident.

Labelling and Assessment

There are many ways of providing information on materials. Manufacturers make their own claims about products, and they can also participate in voluntary labelling schemes designed to highlight a special feature of a product. In some cases, companies are legally obliged to state certain information on products in prescribed formats. There are green labelling schemes for almost every type of product.
There are also schemes for different types of environmental impacts, and for combinations of products and impacts. Good schemes provide an excellent way for companies to advertise to their customers and potential customers that a product has achieved demanding environmental standards. However, given the potential marketing advantages it is not surprising that some schemes may be less than thorough in their appraisals.

Assessment tools can emphasise criteria such as embodied energy, longevity or recyclability, which tends to skew the picture in terms of specification and undervalue the issue of toxicity. As there are few comparative measures of toxicity, it is rarely addressed. A number of organisations, local authorities, councils and European municipalities are using guidelines on materials to control the design and specification process[11].

Costs

The debatable perception that green buildings cost more in capital terms dominates the public domain. Therefore, the tendency has been to seek to argue the case for green buildings on a 'cost-in-use' basis, where the consensus is that they do indeed pay back, even in narrow financial terms and that this pay-back can be even greater where social and environmental costs are also accounted for.

The reality is that, for low budget buildings, incorporating green specification is indeed very difficult. This is in part due to the scarcity of available competitively priced products in the UK. Nevertheless, for the vast majority of buildings above the lowest cost threshold, there are sufficient trade-offs available to specifiers to bring green buildings into line with conventional yardstick costs. These trade offs vary but include adding value through design, reducing servicing costs or simply attention to the supply chain. This is endorsed by a number of independent research studies. Where these trade-offs are not taken account of then capital costs are generally found to increase by 1 – 7 %.[12]

Benign Construction

Many practices are eager to know more about materials and their effects. However the tools available in the UK to satisfy the interest are either in an early stage of development or of limited value. Very few specifically address the issues of chemical toxicity because of the dearth of information. The BRE Green Guide to Specification for instance awards an “A” rating to a very high percentage of appraised elements with significantly varying chemical make-up and cradle to grave toxic impacts. This statistically skewed distribution inevitably raises concerns.

Illustration 4: The Centre for Alternative Technology, Wales

The reception building and shop at the Centre for Alternative Technology (CAT) in Wales is an exemplar of the use of healthy materials – including rammed earth and untreated timber.

Photo source: H Liddell

Notably, products tend to be appraised rather than creative design solutions. Hence a well-detailed, locally procured, solid timber, untreated roof – which has potentially very little adverse impact over its life - does not appear amongst the elemental options of roofing material, because no-one has yet paid for it to be appraised. This is probably inevitable for a commercial scheme but highlights the problems faced by designers looking for a truly wide-ranging and independent view. It is therefore sometimes incumbent upon designers to seek creative design solutions to environmental problems regardless of the certification schemes that exist.

Illustration 5: Brettstapel

A new, healthy floor / wall / roof product popular in Europe – Brettstapel is a prefabricated massive timber construction system made from a low-grade timber species. Untreated planks are joined via dowels removing the need for glue

Photo source: H Liddell

The UK is not well served in terms of basic information and labelling systems for materials and products, which have been routine in central Europe for 20 years, because neither the industry nor its clients have experienced the culture shift that would have been demanding this type of information.

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[4] PM2.5 particulates: man-made particles smaller than 2.5 microns. These have increased dramatically in recent years at least in part due to the shift from coal to waste oil mixes in incinerators, factories, etc.

[5] More information can be found at www.epa.gov.uk

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