Indoor Air Quality in European Earthships: A Study

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Key Words

Off-gassing, construction, harmful substances, building materials

Context of the Study

This study inquires into indoor air quality in European earthships. The analyses regarding air quality of five earthships in four different European countries were carried out by the independent, state-funded *Laboratoire National de Santé Luxembourg* (LNSL). The study was commissioned by the Centre for Ecological Learning Luxembourg (CELL), a non-profit organisation that is developing a public earthship-inspired building that will serve as an educational centre for transition and resilience. The name of this project is Äerdschëff.

While designing the building and preparing the plans, the CELL earthship team was repeatedly asked about the use of old tyres in construction, in particular with regards to residents' health. We studied the existing literature about off-gassing in earthships and found that rubber, insulated from the environment (water, wind, etc.) through being encased in a clay wall, seems to be a fairly inert material (see Edil 2008, Reschner 2012 for an overview). As we studied construction material hazards, we became more widely interested in indoor air quality in buildings, and earthships in particular. When the LNSL offered a complete analysis of the most problematic substances likely to occur inside buildings, we decided to go ahead with examining air quality in earthships. The objective of this study was to test for harmful present in earthships, so as to be able to trace potentially problematic substances and to avoid using similarly risky materials in the Äerdschëff project.

Indoor air quality refers to the quality of the air inside buildings as represented by concentrations of pollutants and thermal (temperature and relative humidity) conditions that affect the health, comfort and performance of inhabitants. Other factors affecting occupants, such as light and noise, are important indoor environmental quality considerations (EPA 2017). The growing proliferation of chemical pollutants in consumer and commercial products, the tendency toward tighter building envelopes and reduced ventilation to save energy, and pressures to defer maintenance and other building services to reduce costs have fostered indoor air quality problems in many buildings (EPA 2017).

The objective of the study is to find out if pollutants are present in these buildings and to eliminate potential sources of harmful substances in the Äerdschëff.

Methodology

To examine the air quality, dust samples were collected inside five European earthships (Romania, Spain, Germany and Scotland) according to a specific sampling protocol. These samples were then tested for different substances: biocides, flame-retardants, phthalates, polycyclic aromatic hydrocarbons, polychlorinated biphenyls and heavy metals.

The test results show that in the categories of biocides, polycyclic aromatic hydrocarbons and polychlorinated biphenyls no thresholds are overstepped. The three remaining categories show some increased levels.

Flame Retardants

In two of the five earthships the flame retardant Tris-2-chloropropyl)phosphate (TCPP) has higher concentrations than it is advised (threshold value: 5 mg/kg, 6,4 mg/kg in Romania, 8,5 mg/kg in Spain). The substance is typically used as flame retardant additive for polyurethane, which is either used in rigid foams for construction works or in flexible foams for furniture.

The Institute for Work Safety of the compulsory German Accident Insurance (*Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA)*) reports that there is no harm to be expected to humans from TCPP. However, there are some concerns that

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exposure to TCPP may impact nervous system development as well as thyroid hormone levels (TFF 2017).

Phthalates

In the German earthship sample there was an elevated result in the case of Diethyl phthalate (DEP) (threshold value: 10 mg/kg, 19 mg/kg in Germany). DEP is mainly used as solvent and softener. As it is a good carrier for fragrances, it is often used in products which have to be of a certain smell (air care products, perfumes, washing and cleaning products), but it is also used in coatings, paints, thinners and paint removers.

In a report composed by the German federal agency for work safety and occupational medicine (*Bundesanstalt für Arbeitschutz und Arbeitsmedizin*), it is stated that DEP is not harmful to human health. Since phthalates are massively present in our environment and can lead to an aggregate exposure that is beyond the safety threshold of, say cosmetic products, it is perhaps important to specify that some studies indicate that DEP and other types of phthalates have an impact on the health of the human reproductive system as well as potentially altering liver and kidney function (DiGangi *et al.* 2002).

Heavy Metals

Heavy metal results show some increased levels.

For nickel, the value in the Scottish case is too high (threshold value: 30 µg/g, result in the earthship: 99 µg/g). Sources for nickel can be ceramic paints, batteries and pigments in plastics, but other sources exist too. Nickel in dust form can cause eye irritations and allergic reactions, but it depends on the solubility of the substance.

Cobalt results are too high in the Romanian, in the German and in the Scottish earthships (threshold value: 5 µg/g, Romania: 11 µg/g, Germany: 7,8 µg/g, Scotland: 21 µg/g). Sources of cobalt can be alloys, colour pigments in glass and glazing. Cobalt can cause abdominal pain and allergic reactions in the respiratory tract.

The arsenic values are exceeding the threshold values in Romania and Germany (threshold value: 4 µg/g, Romania: 5,9 µg/g, Germany: 7,4 µg/g). Sources of arsenic include: wood

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preservation means, metal alloys and semiconductors. Consequences of contact to the metal in dust form can be irritations of eyes and nose, and, in the long-term, inflammation of the lungs.

Discussion and Conclusions

For the categories of flame retardants and phthalates where threshold values were exceeded, human health impacts from the exposure alone are minimal, though they may represent a problem as aggregate pollution. Regarding the category of heavy metals, there could be threats to the health of earthship occupants. This depends on how the substances are assembled and how soluble they are. The results that we obtained would need to be supplemented by further study to determine the source(s) of the pollutant with any certainty.

We take the following lessons from this study to prevent a bad indoor air quality in our project:

- During the planning phase, the materials used will need to be carefully screened in relation to air quality reference databases (e.g. IAC specification) and chosen with regards to their potential emissions of pollutants. Ideally, the materials will also be cross-examined with other characteristics such as embodied energy and capacity for disassembly, etc.
- During the construction phase, it is important to avoid the spread of other pollutants into the earthship through delivery.
- Radon gas soil tests need to be performed prior to commencing construction so exhaust strategies can be designed in.
- It is also important to use dilution as a way to manage pollutants that were not completely avoided, and put into place protocols for properly venting the building to exchange the air on a regular basis in order to ensure building occupants' well being.

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