

German version in: *Wohnung u. Gesundheit* 125, Winter 2007, p. 70-71

Katharina Gustavs: Die atmende Wand [complete text]

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## The Breathing Wall

Written and translated by Katharina Gustavs, Building Biology Consultant (IBN) C.T.

The breathing wall concept goes back to Max von Pettenkofer (1818-1901), one of the most accomplished hygienists of his time and the pioneering founder of occupational and environmental hygiene sciences, as we know it today. He was instrumental in stopping the cholera epidemics in Munich, one of the largest cities in Germany, during the second half of the 19<sup>th</sup> century. By initiating the construction of a central water supply and sewage treatment system, public health improved greatly and he reached celebrity status.

In his dedicated search for better living conditions, von Pettenkofer introduced carbon dioxide measurements as an important indicator of overall indoor air quality. His measurements about air exchange rates in a room with brick walls, a masonry heater and sealed windows led him to hypothesize that the brick walls themselves must let air pass through. Even after having sealed the keyhole and other cracks, the air exchange rate had only dropped about a quarter compared to the rate prior to his sealing efforts.<sup>i</sup> From hindsight, it appears that he forgot to consider the effect the masonry heater would have on the ventilation rate. Thus he proceeded to demonstrate that when air is pumped through a brick cylinder, which is sealed on the outside except for both ends, a candle flame at the other end could be extinguished. In his eagerness to prove his hypothesis correct, he overlooked the fact that the maximum natural air pressure across a wall with ca. 30 Pa is many times lower than the pressure required in his candle-extinguishing experiment (between 700 and 10,000 Pa).

Von Pettenkofer's celebrity status may have been one of the reasons why his hypothesis of the "natural ventilation" through walls was not scientifically debunked until the 1920s.<sup>ii</sup> Though he himself never used the term "breathing wall", this concept took on a life of its own and seems continuing to do so up to our days. The Institute of Building Biology and Ecology Neubeuern, Germany, recommends avoiding the use of the term "breathing wall" because it does not reflect the reality of the complex processes occurring in a wall and usually leads to misconceptions.<sup>iii</sup>

In building biology, a natural home is considered to be a living organism in the sense that it should be – as much as possible – self-sufficient, energy-efficient

and built from natural materials that are part of the natural cycle and not contributing to toxic waste. The roof and wall systems are often referred to as our "third skin," implying that - just like human skin - the building envelope is in constant contact with the environment and plays a crucial role in maintaining a healthy inner climate despite unfavorable outer weather conditions. So let us have a closer look at what does or does not permeate a wall with regard to air and moisture.

### *Air Exchange*

It is true that a constant supply of oxygen-rich air and the reduction of carbon dioxide are essential to a healthy indoor climate. As discussed above, it is a misconception to assume that walls could "breathe" air. Despite their varying degrees of porosity, the air pressure difference between outdoor and indoor air is never high enough to promote a significant air exchange through exterior walls; for a properly installed building envelope only 0 up to a maximum of 4% of the required air exchange can be achieved this way. If air does get through a wall, it is not through the wall itself but through poorly sealed joints, cracks and other building component connections. This, however, is the least desirable way to supply fresh air because it promotes high heat loss in winter, makes for very unpleasant drafts, and potentially invites moisture problems.

In order to ensure a building biology recommended air change rate of about 1 complete change of air per hour, either mechanical ventilation (ideally with a heat recovery system to save energy) or cross ventilation through open windows several times a day are necessary. Massive wall systems (incl. solid wood walls) are especially well suited for natural ventilation methods because their extraordinary heat storage capacity, for example, keeps heat loss at a minimum during the short opening of the windows in winter.

It is interesting to note here that human skin does not breathe air either. All oxygen for our inner organs is supplied by the air inhaled through the nose and/or mouth, which in keeping with the analogy of the "third skin" would be comparable to the window and door openings in a house. Though the uppermost layer of our skin (up to 0.4 mm) can extract oxygen from the ambient air, it does not cross into the body.<sup>iv</sup>

### *Moisture Transport*

When water vapor travels through building materials, this is referred to as water vapor diffusion. Temperature and relative humidity levels affect the speed of diffusion and consequently the amount of water vapor being moved. Since warm air can hold more moisture than cold air, in mixed and moderate climate zones moisture has a tendency to flow from inside out during winter and from outside in during summer (vapor pressure gradient). In addition, many natural building

materials such as clay, brick or solid wood promote this type of moisture transport due to their high capillary activity (hygroscopicity). Any wall system should be designed to prevent vapor condensation from occurring. Building materials that are especially good at wicking away moisture provide an additional insurance that liquid water will never get trapped in the wall. This, of course, only works as long as surface treatments are also highly permeable to water vapor such as silicate paints, lime paints or many natural oil finishes for wood.

The actual amount of water vapor an exterior wall can shuttle to the outside of a building is rather low though it is important for drying out walls and thus for the avoidance of moisture and mold damage. During winter when outside temperatures are low in northern and moderate climates, only about 1 to 2% of the indoor moisture can make it through, for example, a brick wall.<sup>v</sup> Again, it is obvious that the majority of the moisture that is usually generated inside a home needs to be removed through active ventilation of windows and/or mechanical ventilation systems.

#### *Moisture Buffering*

It is true that building and finishing materials with a high moisture buffer or hygric capacity improve indoor air quality tremendously because they help mitigate temporary humidity highs. Many natural building materials are highly hygroscopic and are able to absorb large amounts of water vapor. At an indoor air humidity of 50%, lime-cement plaster, for example, can absorb ca. 1.8 kg/m<sup>2</sup> moisture or solid wood ca. 1.08 kg/m<sup>2</sup> whereas drywall or gypsum board can hold only ca. 0.09 kg/m<sup>2</sup> (each of the above about 2 cm thick and unfinished). But as soon as hygroscopic building materials are finished with, for instance, a standard latex paint with a high vapor diffusion resistance, the water vapor absorption drops considerably.<sup>vi</sup> Therefore it is important to choose surface treatments, which are highly permeable to water vapor such as lime wash, silicate or clay paints as well as relevant natural oil products.

Please note that this important short-term (several hours) moisture buffering effect only relies on the first 1 to 2 cm of the interior wall surface. Thus almost any wall structure can benefit from the moisture buffering effect by, for example, adding a clay plaster or wood wainscoting.

It is unclear why the “breathing wall concept” continues to persist when it is riddled with so many misconceptions. What is clear, however, is that any building envelope has to meet two major challenges: First, not to let any water in. Second, if water does get in, to let it out again. In contrast to the widespread use of vapor barriers, building biology favors the so-called flow-through design that is transparent to water vapor diffusion but windproof and protected against condensation water. It allows water vapor to freely pass through the wall

assembly's components without condensing and supports drying through capillary activity.

### **Sorption of Odors and Toxins**

Hygroscopic building materials with open pores and a capacity for water vapor diffusion cannot only buffer indoor air humidity levels, but, within certain limits, they can also absorb odors and toxins, which is very important for a healthy and well-balanced indoor climate. Therefore the smell of such homes is often perceived as much more pleasant compared to many conventional homes.

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<sup>i</sup> Dr. Max von Pettenkofer: Über den Luftwechsel in Wohngebäuden. Literarisch-Artistische Anstalt der J.G. Cotta'schen Buchhandlung, München 1858.

<sup>ii</sup> Raisch, Erwin: Die Luftdurchlässigkeit von Baustoffen und Baukonstruktionsteilen. Gesundheitsingenieur 1928; Issue 30 (Forschungsheim für Wärmeschutz München)

<sup>iii</sup> Winfried Schneider: 40 Jahre Baubiologie – Klischees, Innovationen, Trends. Wohnung und Gesundheit 2006; 120: 12-14.  
[www.baubiologie.de/site/zeitschrift/artikel/120/12.php](http://www.baubiologie.de/site/zeitschrift/artikel/120/12.php)

<sup>iv</sup> Stücker M et al.: The cutaneous uptake of oxygen contributes significantly to the oxygen supply of human dermis and epidermis. Journal of Physiology 2002; 538: 985-994.

<sup>v</sup> Schneider W, Schneider A: Baubiologische Baustofflehre + Bauphysik. Course Module 7 of IBN Building Biology Correspondence Course 1998, p. 67.

<sup>vi</sup> Moisture uptake of building materials within 3 hours while ambient air humidity increased from 40% to 80%: Lime plaster (13 g/m<sup>2</sup>), clay plaster (30 g/m<sup>2</sup>), lime plaster with standard latex paint (below 9 g/m<sup>2</sup>)  
Schneider W, Schneider A: Baubiologische Baustofflehre + Bauphysik. Course Module 7 of IBN Building Biology Correspondence Course 1998, p. 37.