Aspects of Breathability Natural Fibre Insulation

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therma fleece Nature's finest insulation

What is “Breathability”?

1. The ability of a product or material to allow the diffusion of water vapour – **vapour permeability**? or,
2. The ability of a product or material to actively buffer humidity through capture & release of water vapour – **humidity buffering**? or,
3. The ability of a porous material to move moisture through capillary transfer?, or
4. All of the above – **vapour permeability & humidity buffering**?

vapour permeable materials = breathability?
humidity buffer materials = hygroscopicity?
porous capillary materials = capillarity?

CONFUSING?

Hygroscopicity

- Hygroscopicity is a material property like density
- To have use, it needs scale and context
- Hygroscopicity isn't always useful or beneficial
- Not all hygroscopic materials buffer humidity or breathe
- To usefully buffer humidity a hygroscopic material must:
  - Capture and release water under normal conditions
  - Capture and release water without significantly altering the physical nature of the material or its surroundings

Hygroscopic Classification

- Shows moisture content change with RH% and Temp

Classification	Mass gain at 24h @ 25°C & 80% RH
Slightly hygroscopic	<2% and ≥ 0.2%
Hygroscopic	<15% and ≥ 2%
Very hygroscopic	≥ 15%
Deliquescent	Forms a Liquid

- Doesn't show how available or "bound" the water or how much work it can do.
- For this we need to look at the concept of **water activity**

Water Activity (a_w)

- Well illustrated in a multi-component system where moisture is in balance and structural and biological stability maintained

Water Activity (a_w)

- RH generating potential of a material vs pure water
- Consider an enclosed building element
- All components are in thermodynamic equilibrium
- Chemical potentials of water in materials (e.g. NFI) and void are the same

$$\mu_w^{\mathbf{Material}} = \mu_w^{\mathbf{vapour}}$$

- V.P exerted by the material (P_w) and *V.P* in the void (P_w) are the same
- a_w is P_w relative to the V.P exerted by pure water in an enclosed system (Saturation VP – P_0)

Water Activity (a_w)

- Water activity is calculated in the same way as ERH.
- Divide the VP (P_w) of material or void by the SVP (P_o)
- In the case of the void, we express this as % and call it Equilibrium Relative Humidity (ERH)

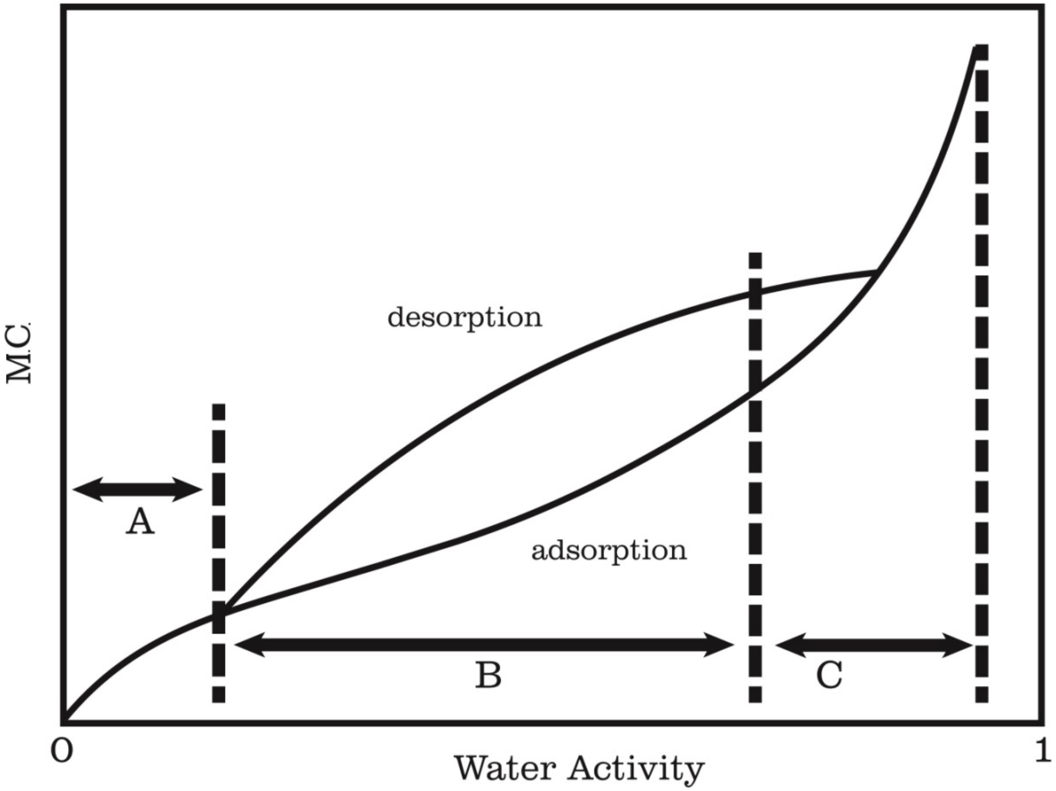
$$ERH = \frac{P_w}{P_0} \times 100\%$$

- In the case of the material, we express it as a fraction and call it Water Activity (a_w)

$$a_w = \frac{P_w}{P_0}$$

- a_w allows us to think about moisture in a material in the same way we think of moisture in the air $a_w = ERH$

Water Activity Zones



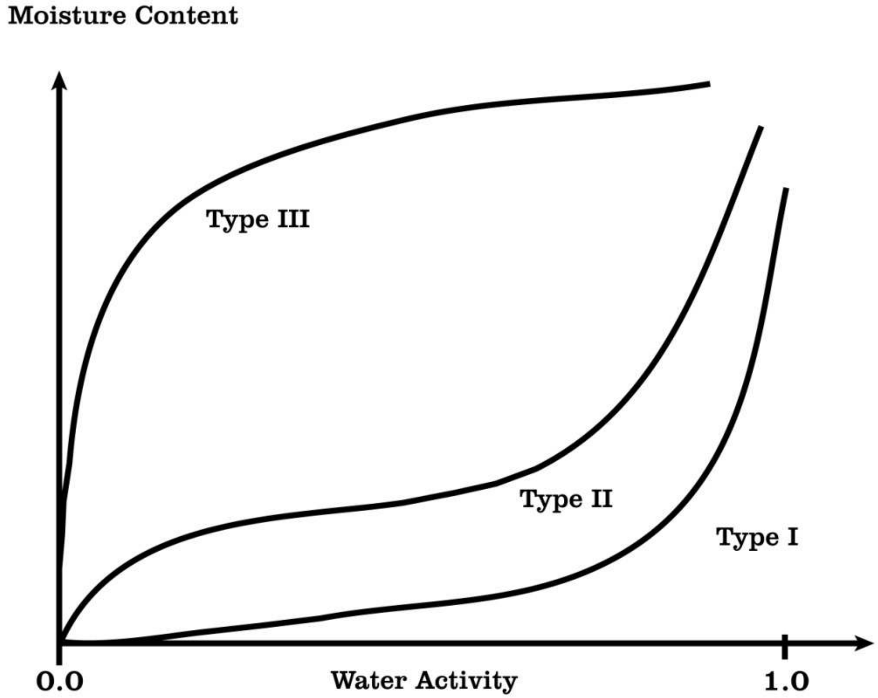
A – mono-layer water, strongly bound

B – poly-layer water, less strongly bound

C – free water

Zone B is the humidity buffering zone

Sorption Isotherms & a_w



Type I capillary porous materials (brick)

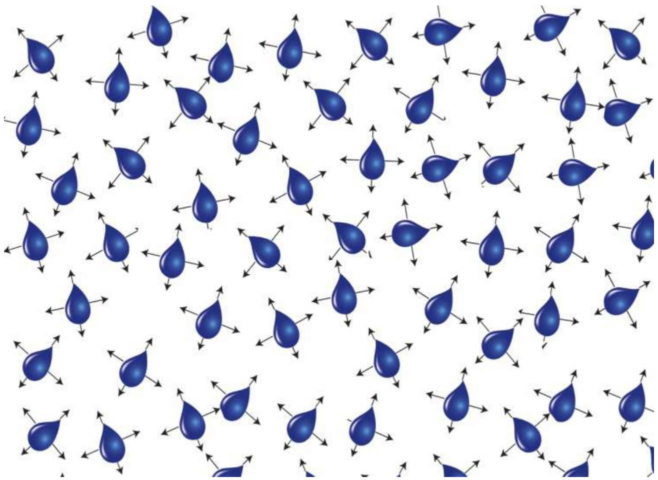
Type II – natural fibres

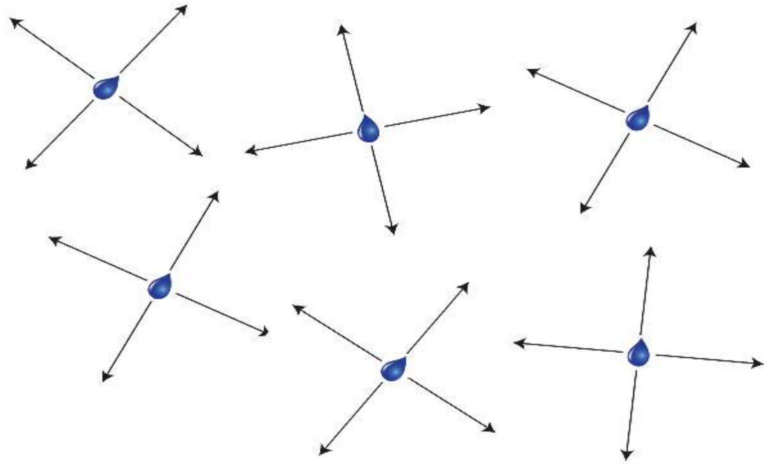
Type III – anti-caking agents

- Widely used for moisture properties of materials & systems. Occasionally referenced in building context
- Important for understanding humidity buffering

a_w versus Moisture Content

- Material can have a high **m.c.** but a low a_w





- Higher m.c.
- Stronger water bonds
- Lower V.P.
- Lower a_w

- Lower m.c,
- Weaker water bonds
- Higher V.P.
- Higher a_w

a_w & Microbial Activity

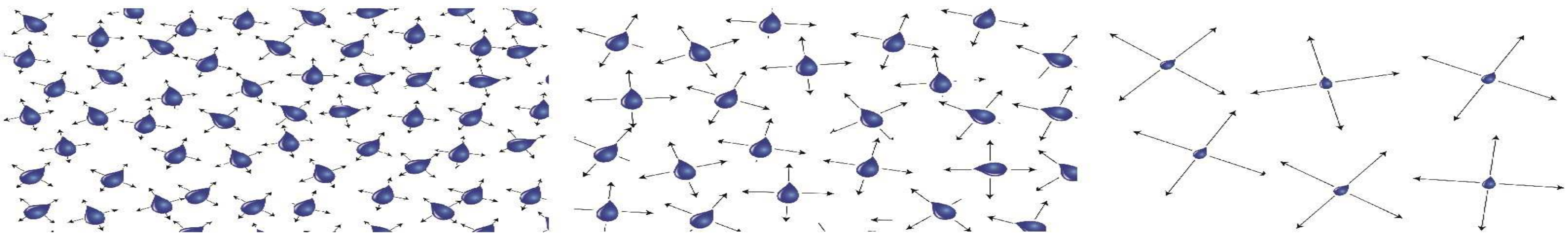
- Microorganisms have a limiting a_w below which they will not grow. Value same as the limiting RH%
- a_w not m.c determines the lower limit of available water
- Each microorganism has an a_w level below which it cannot grow.

Organism	Limiting a_w
Most bacteria	<0.9
Most yeasts	<0.8
Most fungal activity	<0.7
All microbial activity inhibited	<0.6

Source: AECB Factsheet – Moisture Requirements for Mould Growth

a_w & Moisture Migration

High **Moisture Content** **Low** →

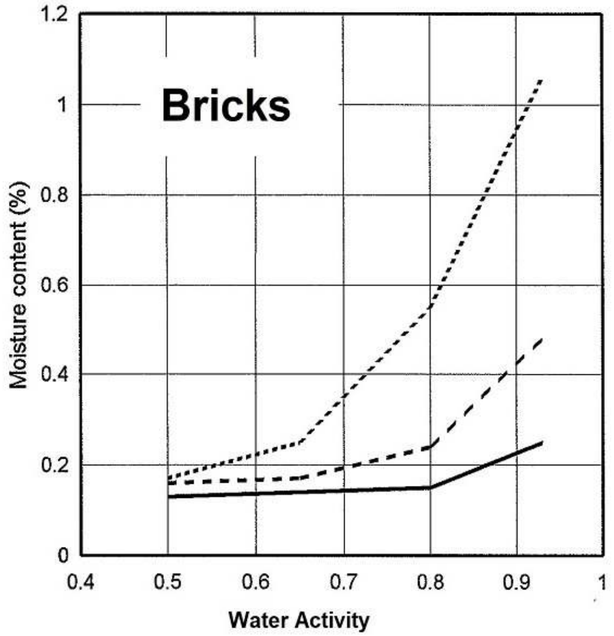


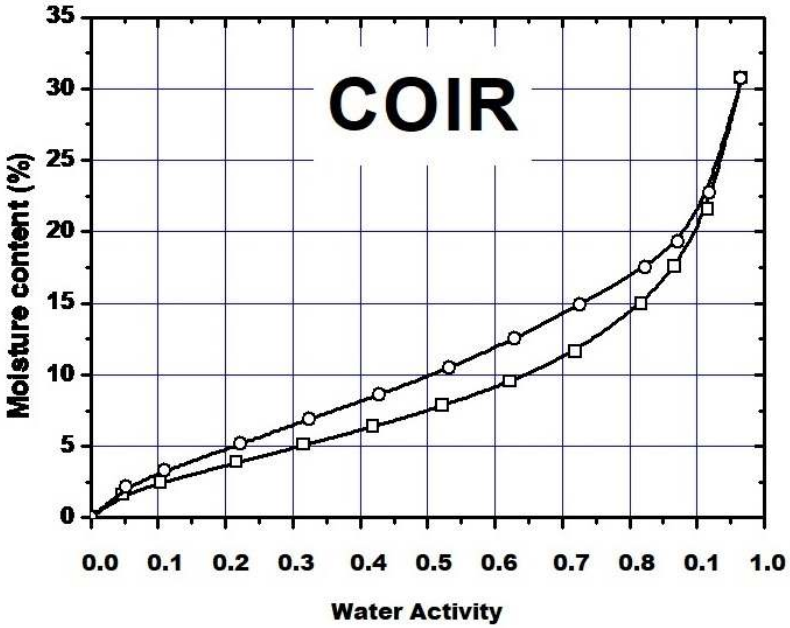
← **Low** **Water Activity (a_w)** **High**

Moisture Actually Moves from High to Low a_w ←

- Moisture migrates from regions of high a_w to regions of low a_w not between areas of unequal m.c.
- Can influence the direction of moisture movement

a_w Comparison





Brick has high a_w at low m.c.

Coir has low a_w at low m.c.

Temperature

- Temperature decreases, V.P from NFI decreases, a_w decreases, ERH decreases.

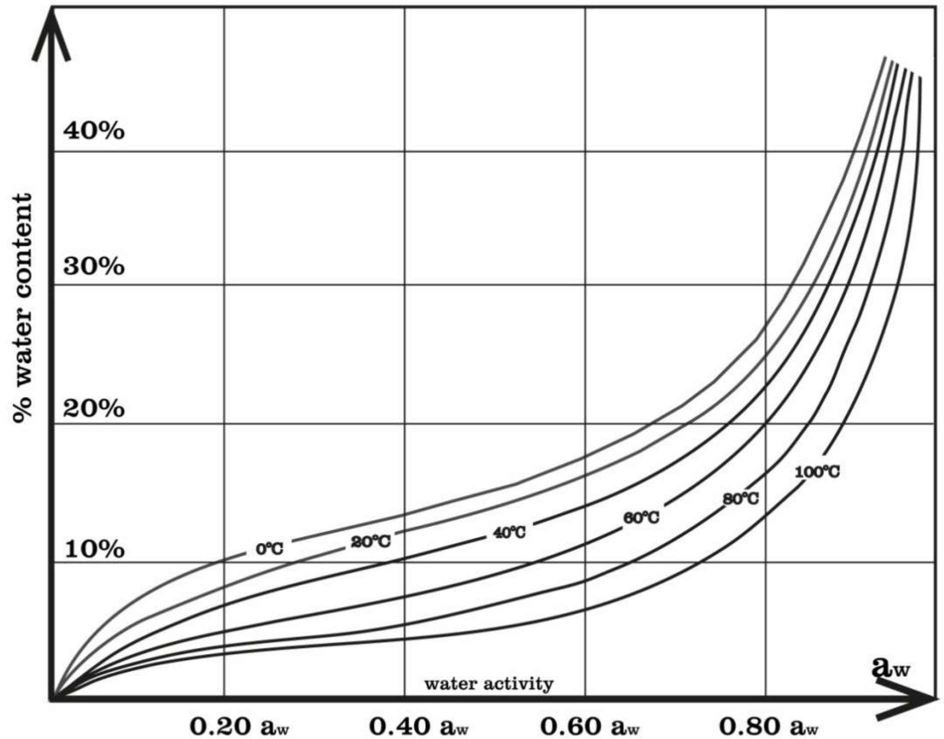
m.c.	Temp	ERH	a_w	VP	Dew Point
14%	25°C	68.0%	0.68	16.3 mmHg	18.7 °C
14%	20 °C	64.4%	0.64	11.2 mm Hg	13.0 °C
14%	15 °C	60.0%	0.60	7.1 mm Hg	7.4 °C

- Temperature decreases, saturation point of air increases & RH% increases

a_w decreases with decreasing Temp.

RH% increases with decreasing Temp.

Sorption Isotherms & Temperature



SI Sorption Isotherm

Humidity Buffering

As T^o falls RH rises and a_w of NFI falls.

What does this mean?

•NFI wants to lower RH to the same level as its $\mathrm{a_w}$.

•Air wants to raise a_w to the same level as its RH.

Who wins?

•Moisture content of NFI changes by approx 300-900 g/m^3 for every 0.05 change in a_w (5% ERH eq.)

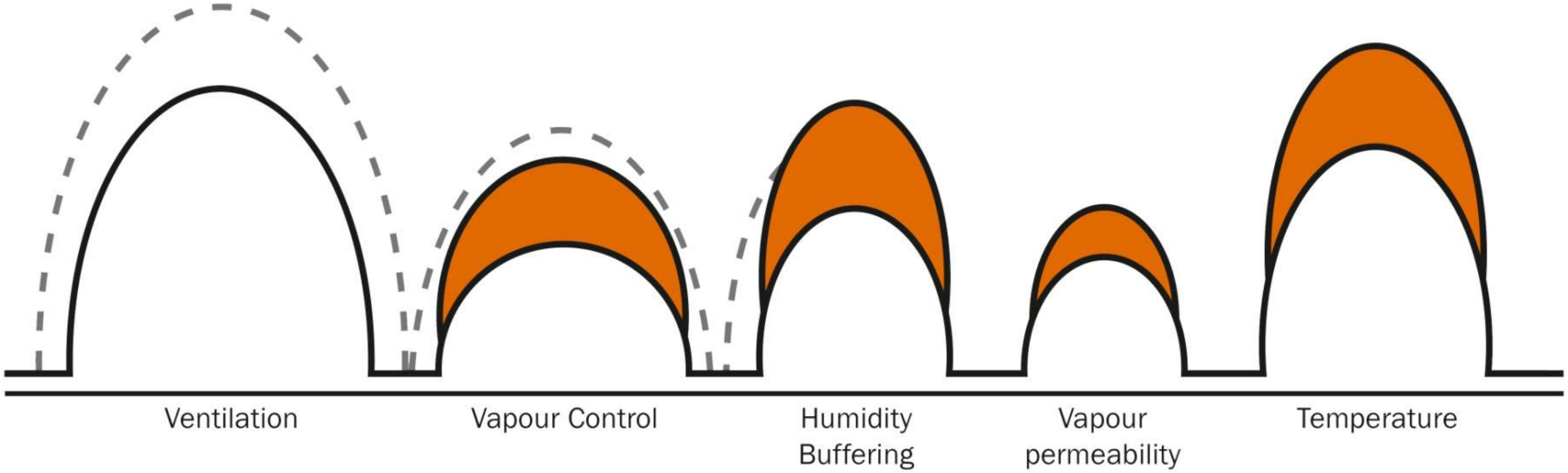
•Moisture content of air changes by approx 1-2 g/m^3 for every 5% change in RH.

Result:

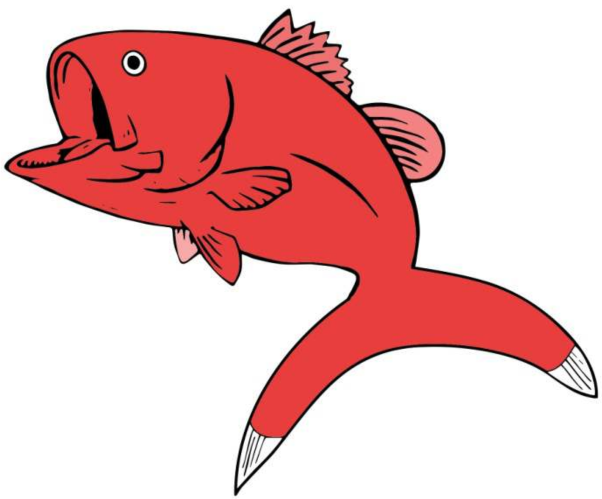
Small increase in a_w of NF, large decrease in RH of air.

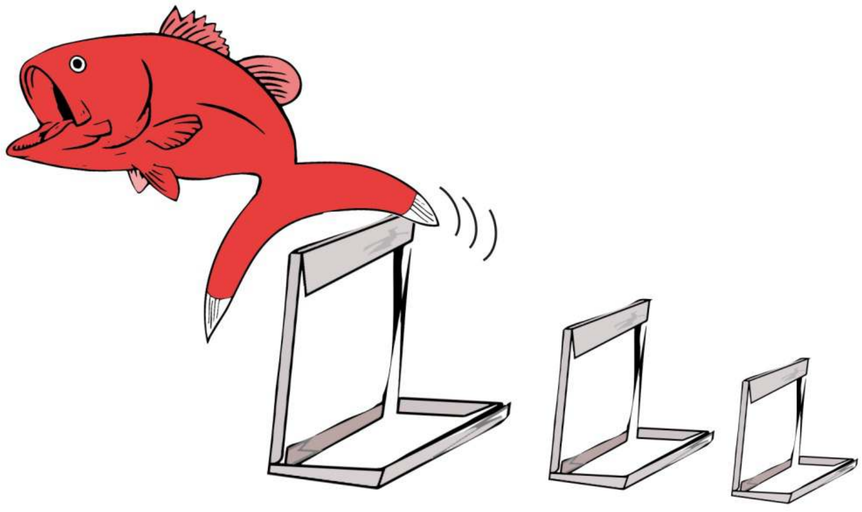
Hurdle Technology

- A.K.A "combined methods technology"
- Intelligent combination of hurdles or controlling factors to secure microbial safety, durability, etc.
- Vapour openness and moisture buffering are hurdles.
- Different hurdles have different impacts in different situations but they are all controlling factors.



Breathability in Building





Herring? or Hurdle?