Monitoring and Assessment of Atmospheric Moisture Imbalance: Elimination and Prevention of Condensation and Mould in Buildings

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Abstract

An innovative method known as Building Moisture Index (BMI) has been applied in hundreds of properties suffering of surface condensation and mould growth in order to quantify and rectify indoor atmospheric moisture imbalance. BMI system is a protocol, a method and a computer program that processes, assesses and reports environmental data in a fast, reliable and objective scientific-technical manner. An example is presented showing the causal factors diagnosed by the BMI code. The ventilation system was in this case improved, and moisture issues were automatically rectified, being this indicated by *very high* going down to *low* moisture imbalance scores, before and after installation, respectively. Following appropriate methods and protocols for environmental monitoring and assessment of moisture imbalance of indoor environments may support better retrofitting works to eliminate or avoid condensation damp and mould problems in residential buildings. Peer-review under the responsibility of the organizing committee of the ICMB21.

Keywords: Residential buildings; Retrofitting works; Atmospheric moisture; Condensation; Mould growth; Environmental monitoring

Nomenclature

a_w	Water activity				
D_p	Dew point				
RH	Relative humidity	RHe_{air}	External relative humidity	RHi_{air}	Internal relative humidity
fR_{si}	Temperature factor				
T	Temperature	Te_{air}	External air temperature	Ti_{air}	Internal air temperature
Ti_{surf}	Surface temperature				
VPE	Vapour pressure excess (differential vapour pressure)				

1. Introduction/Background

The UK has a very large stock of old housing much of which is constructed with solid brick or stone walls, which are difficult to keep warm and dry [1]. Fuel poverty can result in people living in cold and poorly ventilated homes; rarely aerated to retain heat indoors. Lack of heating and ventilation can result in low indoor temperatures and high indoor air humidity that may trigger condensation and mould [1,2]. In addition, the inherent poor thermal efficiency of uninsulated older buildings and a lack of airtightness may cause a decrease of indoor surface temperatures and increase surface condensation risk. Besides, small high occupancy dwellings, contemporary lifestyles with high moisture production (e.g. more daily showers and laundries than past times) is affecting the capacity of buildings to manage atmospheric moisture effectively [3]. Consequently, ca. half a million residential buildings in the UK are affected by condensation and mould problems [4].

Tackling poor housing to meet the Decent Homes Standard, reducing carbon emissions and making homes more energy efficient has been part of UK Government objectives for the last couple of decades. However, apart from insulating homes to reduce heat loss, ventilation and damp control measures also need to be considered as part of any retrofitting plan. This is because greater air tightness can lead to condensation if appropriate ventilation is not provided. Measures to eliminate damp and mould or preventing these issues are essential for delivering appropriate retrofitting works. A combination of measurement and modelling is necessary to provide evidence of benefits, risks, limitations and unintended consequences of retrofitting projects.

The aim of this work is to show the significance of environmental monitoring, collection, processing environmental data and reporting indoor atmospheric moisture imbalance assessment, risk of surface condensation and mould growth in a robust manner. An innovative diagnostic method/program (BMI) [5] has been applied to collect, process and report environmental data in a property where moisture imbalance is assessed and corrected afterwards. This may support the design, monitoring and evaluation process of retrofitting projects while providing evidence of this to inform better future retrofit strategies.

2. Methodology

A set of three environmental sensors have been used to monitor a property (bungalow) with surface condensation and mould problems. One data logger collecting indoor ambient air T and RH (Lascar EL-USB-2) plus one surface T sensor (Lascar EL-USB-TC-T type) have been gathering measurements in the main problem area room (bathroom). A third sensor has been placed outdoors to record the weather conditions along the monitoring period. Data has been gathered during 2 weeks at 30 min intervals. BMI diagnosis method/code [5] has been used to assess moisture imbalance, risk of surface condensation and mould growth.

3. Results and discussion

The results of environmental monitoring are shown in Table 1 which display the raw environmental parameters collected by the sensors and calculated parameters (e.g. a_w , VPE) by BMI code in the property with problems of condensation and mould before and after changing the ventilation system. An intermittent extraction fan has been replaced by a continuously running mechanical ventilation system with humidistat. Table 1 and Figure 1 show how environmental parameters as a_w , RH_{air} and VPE go from higher to lower values while the total BMI imbalance score goes from *very high* imbalance (4.5) to a *low* imbalance score (2.2). Despite the thermal envelope still being poor, with risk of surface condensation, after changing the ventilation system, it is adequate when in conjunction with a_w values (i.e. surface RH), and overall moisture imbalance and risk of mould growth is *low*.

BMI diagnostics may support the design, monitoring and evaluation process of retrofitting projects complying with PAS 2035:2019 by assessing the indoor environment before and after energy efficiency measures (EEM) are taken. This can assess if intended outcomes (e.g. elimination of mould) are achieved, or to identify unintended issues (e.g. surface condensation).

Table 1. Environmental parameters monitored in a property with condensation and mould before and after changing the ventilation system

Property	T_{air} (°C)	RH_{air} (%)	T_{surf} (°C)	T_{air} (°C)	RH_{air} (%)	VPE (kPa)	a_w	fR_{si}
Before	3.5 ± 2.7	78.9 ± 10.0	13.9 ± 1.8	19.2 ± 1.6	59.1 ± 6.8	0.7 ± 0.2	0.8 ± 0.1	0.7 ± 0.1
After	5.2 ± 3.7	81.2 ± 10.5	15.7 ± 1.3	18.9 ± 1.4	50.3 ± 4.9	0.4 ± 0.2	0.6 ± 0.1	0.8 ± 0.1

Figure 1. (a) graphs and BMI score of moisture imbalance BEFORE changing ventilation; (b) graphs and BMI score AFTER changing ventilation

4. Conclusions

The BMI diagnostic method allows processing, assessing, and reporting environmental data and provides:

- Standardised, accurate, fast and reliable scientific-technical interpretation of indoor atmospheric moisture balance / imbalance
- Impartial technical evidence of atmospheric moisture imbalance and identification of problems / causal factors
- Help to identify potential solutions to quantify, rectify condensation and mould
- Evidence for retrofitting projects by assessing indoor environment before and after installation of EEM
- Better indoor air quality and healthier moisture-balanced living environments

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