International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org Volume 3 Issue 1 ǁ January. 2014 ǁ PP.44-50

Effect of Indoor Air Humidity on Human Health

[1]L.B.Diwakar, [2]Prof. A.M.Patil, [3]Prof. NarendraDeshpande
[1]*Dept. of Mech.engg. PVPIT, Sangli, Maharashtra, INDIA*
[2]*Dept. of Mech.engg. PVPIT, Sangli, Maharashtra, INDIA*
[3]*Dept. of Mech.engg. KIT, Kolhapur, Maharashtra, INDIA*

ABSTRACT: *A review of the health effects of relative humidity in indoor environments suggests that relative humidity can affect the incidence of respiratory infections and allergies. Experimental studies on airborne-transmitted infectious bacteria and viruses have shown that the survival or infectivity of these organisms is minimized by exposure to relative humidities between 40 and 70%. Nine epidemiological studies examined the relationship between the number of respiratory infections or absenteeism and the relative humidity of the office, residence, or school. The incidence of absenteeism or respiratory infections was found to be lower among people working or living in environments with mid-range versus low or high relative humidities. The indoor size of allergenic mite and fungal populations is directly dependent upon the relative humidity. Mite populations are minimized when the relative humidity is below 50% and reach a maximum size at 80% relative humidity. Most species of fungi cannot grow unless the relative humidity exceeds 60%. Relative humidity also affects the rate of offgassing of formaldehyde from indoor building materials, the rate of formation of acids and salts from sulfur and nitrogen dioxide, and the rate of formation of ozone. The influence of relative humidity on the abundance of allergens, pathogens, and noxious chemicals suggests that indoor relative humidity levels should be considered as a factor of indoor air quality. The majority of adverse health effects caused by relative humidity would be minimized by maintaining indoor levels between 40 and 60%. This would require humidification during winter in areas with cold winter climates. Humidification should preferably use evaporative or steam humidifiers, as cool mist humidifiers can disseminate aerosols contaminated with allergens.*

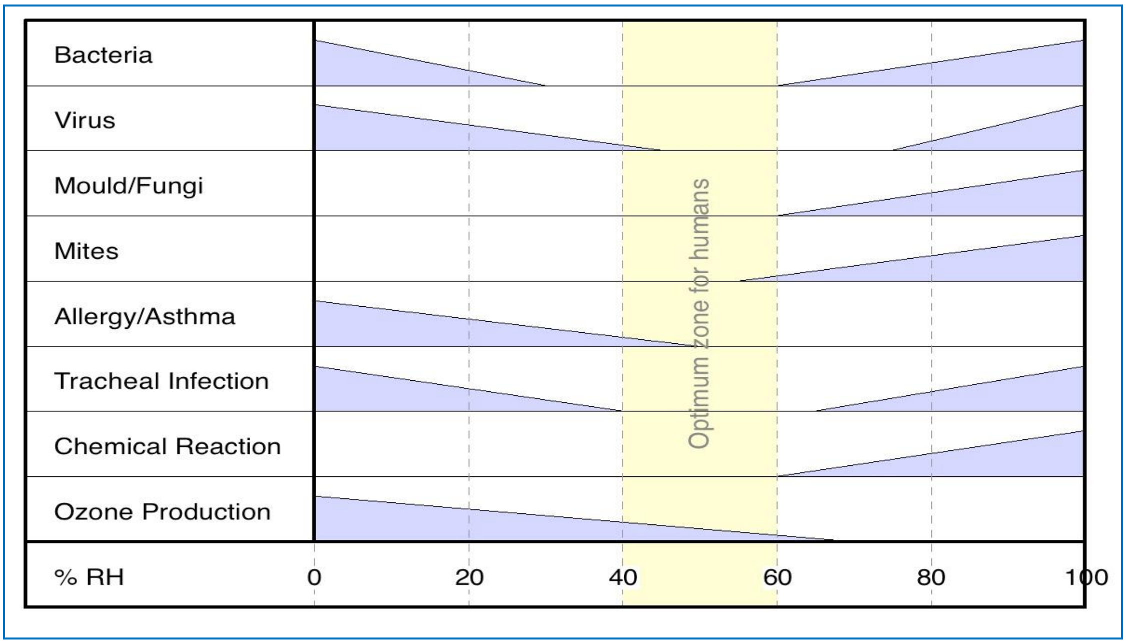
KEYWORDS: *Relative humidity, allergies, building materials, air quality*

I. INTRODUCTION

Indoor air quality is determined by a constantly changing interaction of complex factors that affect the types, levels and importance of pollutants in the indoor environment. It is a major concern to businesses, building managers, tenants and employees because it affects the health, comfort and productivity of building occupants. The quality of the indoor air is expressed as the extent to which human requirements are met. By definition, an acceptable indoor air quality is defined as air in which there are no known contaminants at harmful levels and to which a substantial majority of the people are not dissastified. The quality of the indoor air depends on both the quality of the outdoor air and on the strength of emissions from indoor sources. To satisfy comfort needs, indoor spaces must receive a quantity of tempered outdoor air and a sufficient quantity of clean air to create an acceptable indoor air quality. Similarly, to satisfy health ventilation needs, indoor spaces must receive air that is free from hazardous chemical or microbiological contaminants. Indoor air quality is influenced by changes in building operation, occupant activity and outdoor climate.

II. HUMAN HEALTH AND AIR QUALITY ISSUES

There is real and increasing concern that indoor conditions can adversely affecthuman health and well-being, including that they are a factor in breathing relateddisability. Issues concerning health effects of buildings are complex, and a widerange of environmental and genetic factors are involved. Consequently, there hasbeen no conclusive evidence on causes and slow progress towards determining appropriate responses. Meanwhile, in recent decades, the problems of breathingrelated disabilities have got notably worse.Evidence indicates that 1 in 13 adults and 1 in 8 schoolchildren in the UK currentlysuffer from asthma whilst over 40% of people suffer from some kind of allergy.5 Principle triggers include damp, relative humidity (both high and low), theproliferation of dust mite allergens and the presence of other known allergen suchas formaldehyde. A danger of close controlled ventilation systems is that they can result in the internalenvironment oscillating rapidly between the optimum of 40 -60% humidity. Thisrapid oscillation can create the worst of situations by generating all of the conditionsin which health problems arise. There is little research identified into the potential for improved conditions by enabling the changes to happen more slowly using passivemeans such as hygroscopic materials.



Factors affecting indoor air quality

The following four elements are involved in the development of indoor air quality problems: source; HVAC systems; pollutant pathways and building occupants.

Source

Air pollution sources can be described as fitting into one or a combination of the followingcategories: contamination from indoors, outdoors, faulty HVAC systems, through human activities (metabolism, cooking, washing, etc), and building components and furnishings.
These pollution sources contribute to the deterioration of the indoor air quality.

HVAC - systems

It is anticipated that a properly designed and an efficient HVAC system will perform the following activities within the framework of indoor air quality satisfactorily:
- provide thermal comfort;
- distribute an adequate amount of outdoor air to meet the ventilation needs of occupants; and
- isolate and remove odours/contaminants through pressure control, filtration and exhaust fans.

HVAC systems includes all heating, cooking, humidification, dehumidification and ventilation equipment serving a building.

Pollutant pathways

One or more pollutant pathways connect the pollutant source to the occupants and a driving force exists, for example, buoyancy force, to move pollutants along these pathways. The air flow patterns in buildings results from the combined action of mechanical and naturalventilation systems (e.g. through infiltration) as well as from human activities. Pressure differentials created by these forces move airborne contaminants from areas of relatively high pressure to areas of relatively low pressure through any available opening. All components of the building (walls, ceilings, floors, penetrations, HVAC equipment and occupants) interact to effect the distribution of contaminants. Natural ventilation exert an influence on air movement between zones and between the building's interior and exterior areas. For leaky buildings, there is the tendency for the disruption of the indoor air circulation by the stack effect and wind pressure. Air movement from higher to lower pressure can produce many patterns of contaminant distribution, including local circulation in the room containing the pollutant source:

- air movement into adjacent spaces that are under lower pressure;
- movement from lower to upper levels of the building; e.g. as in thermally-driven flows, using thermal plumes; and
- air movement into the building through either infiltration or re-entry of exhaust air.

Building occupants

Building occupants are considered as source of contaminants by virtue of their metabolism and activities (e.g. cooking, washing, etc). Groups that may be particularly susceptible to the effects of indoor contaminants include, but are not limited to;
- allergic or asthmatic individuals;
- people with respiratory diseases;
- people with suppressed immune systems, due to disease or other causes; and
- susceptible persons, e.g. children and the elderly.

Perceived air quality may be expressed as the percentage of dissatisfied persons, that is, those persons who perceive the air to be unacceptable just after entering a space. The pollution generated by standard person is referred to as one olf. Standard person refers to the average sedentary adult office worker, who feels thermally neutral, that is, such person is not influenced thermally (Fanger et al 1988). The strength of most pollution sources indoors may be expressed as persons equivalents. For example, one decipol is the perceived air quality in a space with a pollution source strength of one olf, ventilated by 10 l/s of clean air (Fanger et al 1988). The next sub-section is a discussion on factors influencing indoor air quality and their classification.

Impact of humidity on building performance and health

Humidity in indoor spaces is one of the most important factors in the determination ofindoor air quality. High indoor humidity is a major contributor to the accumulation of moisture in the building envelope. This often results in dampness within the building envelope and subsequent health-related problems for the occupants. Moderation of the indoor relative humidity is a pre-requisite for a healthy building because it affects the perception of indoor air quality, thermal comfort, occupant health (asthma, respiratory illness, etc), building durability, material emissions and energy consumption. Humidity extremes can also create other indoor air quality problems. Excessively high or low relative humidities can produce discomfort. High relative humidities can promote the growth of mould and mildew on building surfaces. Normally few problems occur when the relativehumidity is between 30% and 70%, assuming that no condensation occurs (Oldengarn et al 1990). SiHealth aspects of indoor air quality.

A number of pollutants including building materials are of much concern for human health. Exposure to such pollutants in the air may provide a certain health risk (e.g. respiratory illness). As a measure of awareness and to limit the health risk to a low level, an extensive list of maximum permissible concentration and the coresponding exposure times to individual chemicals in the air has been published. (Air Quality Guidelines for Europe1987). For example, the Threshold Limit Values (TLV) exist for individual premises. These are applicable to work places where chemicals are used routinely in the production process. In offices and similar work places, exposure to any individual pollutant is typically much lower than the situation in the industry.The exposure is characterised by a wide spectrum of compounds at low concentration levels from building materials, furniture, office equipment, human metabolism and outdoor air. Other pollutants within the health risk category are: radon gas, gases from landfill or waste sites, combustion products, formaldehyde, volatile organic compounds (VOC), metabolic gases, micro-organisms and humidity. These pollutants are discussed in the next sub-section.milarly, low relative humidity causes irritation of the skin and the eyes of the occupants.

Mitigation Strategies and Energy Efficiency

This chapter comprises of a brief overview of the guidance on how design cancontribute to delivering both good indoor air quality and energy efficiency.

5.1 **Ventilation and Infiltration**

The rate of air exchange within a building is an important factor in the accumulation of many indoor pollutants.It is important to distinguish between ventilation and infiltration. Infiltration refers touncontrolled seepage of air into a room or a space through for example cracks inthe building fabric, around windows and under doors. Reducing infiltration bysealing holes and cracks in the building fabric, draught proofing windows and doorsand creating draught lobbies and installing internal doors can all be effectivemeasures in reducing the flow of pollutants into, and the heat lost out of, a building.

They are generally simple and cost-effective to employ and maintain. However,attention is required to ensure that the airflow throughout a building is not overlyrestricted. The requirement for fresh air and the need to disperse and removeinternal pollutants and moisture is the limiting factor when adopting such measures.Ventilation is the design of openings or systems to provide a desired air exchange rate that is sufficient to remove or dilute smells, airborne pollutants and moisturefrom occupied spaces. Ventilation should be specifically designed to removemoisture and pollutants from the internal environment.

The extent to which theseelements are present will influence the ventilation requirement. The issues aretherefore interconnected. There is no standard approach to ventilation. Each roomin a building needs to be considered individually and no single ventilation strategywill suit all spaces within a building due to differences such as occupancy patternsand use.Ventilation can involve mechanical systems to move air. Alternatively it can exploitnatural forces such as the stack effect and the differing pressures on a buildingfaçade to create the required air movement. Using passive measures to controlhumidity (such as hygroscopic materials (see 0)) and avoiding polluting building materials can reduce the requirement for ventilation and increase potential energysavings. Ensuring that a building is well maintained can have a significant impact onthe presence of damp and therefore can also impact the ventilation requirement.Contemporary best practice in building design is moving from a strong reliance onmechanical systems towards exploitation of natural forces – with mechanical systems as supports for natural systems rather than as substitutes for them. Insome circumstances, it may be beneficial to seal windows and doors next to busyroads where pollution is higher, or locate inlets for mechanical ventilation systemsaway from busy roads.Air quality sensors or occupancy sensors can be used to improve the effectivenessof ventilation strategies. Sensors that monitor CO2 or indoor humidity levels areincreasingly used to activate mechanical systems or to draw attention to the need tocontrol vents or window openings, in response to indoor air quality. This can be aneffective means of controlling ventilation in buildings or rooms with varyingoccupancy such as occurs in schools, museums or sports buildings. These can befitted retrospectively. Infrared sensors can also be installed to adjust ventilationrates according to whether a space is occupied or empty. Such systems needeffective control, calibration and maintenance, but can reduce energy consumption.

5.1.1 Ventilation in Traditional Buildings

The vast majority of traditional buildings were passively ventilated with varyingresults. In many cases some additional ventilation such as an extractor fan in akitchen or bathroom has been retrospectively installed. Subsequent work may haveremoved or restricted original sources of ventilation. Internal doors may have beenadded and chimney and flues sealed, blocking traditional airflow paths. Some traditional buildings will have undergone more extensive refurbishments and/orchanges of use. Floor plans may have changed and additional floors been added.Due to the leaky nature of older buildings, energy efficiency measurespredominantly focus on reducing air infiltration. This has to be done in a way thatgives full consideration to the management of moisture and indoor pollutants.Reducing the amount of ventilation or infiltration in traditional buildings throughmodification or renovation can potentially have a serious impact on the ability of thebuilding to deal with indoor pollutants and moisture and needs to be consideredcarefully. In traditional rooms with insufficient ventilation, there would be benefit in increasingventilation rates particularly in areas with a higher concentration of pollutants ormoisture. For example, if sub floor vents have been blocked then this could have animpact on the ability of the building to deal with ground moisture and the removal ofradon. Re-establishing such ventilation paths would generally be beneficial.

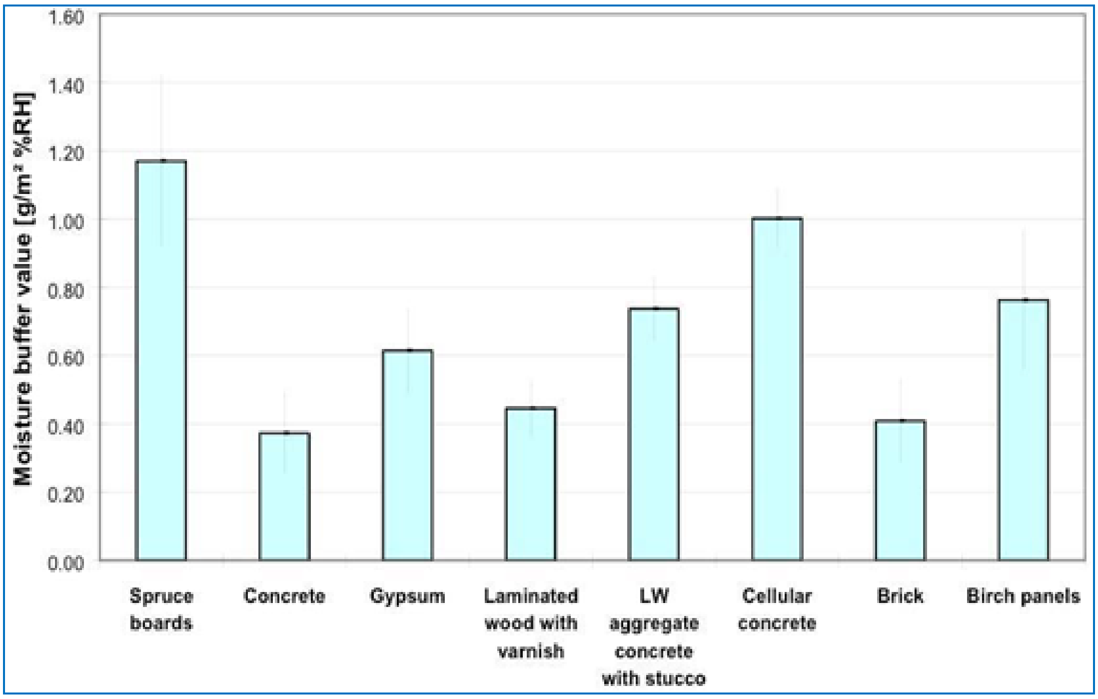
5.2 Relative Humidity (RH)

Relative humidity is a measure of the water vapour present in a gaseous mixture ofwater and air. It is expressed as a ratio between the amount of water present in theair at a given temperature over the maximum amount that could be present in the airat that temperature. The maximum relative humidity (i.e. 100% RH) is referred to asthe dew point.

Maintaining an adequate relative humidity is an important factor in creating a healthyindoor environment. High indoor relative humidity can lead to mould growth anddust mite proliferation. High or low relative humidity can increase the occupants'susceptibility to bacteria and viruses as well as increasing symptoms of allergicrhinitis and asthma. Maintaining a relative humidity in the range of 40 – 60 % isconsidered optimum. Traditional buildings deal with moisture in the air through acombination of ventilation and passive moisture management, with varying success

III. MATERIAL SELECTION

Many modern synthetic materials and some traditional materials can be deleteriousto indoor air quality. Risks can be posed during and directly after application of thematerial, when concentrations of associated pollutants are highest, or over aprolonged period of time. As is the case with many chemicals found in the indoorenvironment there is often scientific uncertainty over the risk posed to humans. This is due to the large number of chemicals currently present in the indoor environment.Of the 75,000 chemicals in common commercial use, only 3% have been tested forcarcinogenicity21. At the beginning of the 20th Century around 50 materials wereused in buildings. There are now around 55,000 building materials are available andover half are manmade22. The Royal Commission on Environmental Pollutionhighlighted our current failure to secure the public:"… the current system for managing the risks from chemicals fails to secure publicconfidence and is overloaded by the massive backlog of chemicals waiting to beassessed. … A more inclusive, precautionary and effective approach is urgently required.”23Where there is scientific uncertainty over the safety of a material, and plausible evidence to indicate that it has the potential to pose a risk to human health and theenvironment, the precautionary principle can be adopted. This essentially meansthat scientific uncertainty should not come in the way of introducing measures toprotect the quality of the internal environment. For example, many chemicals havebeen found to be animal carcinogens, but establishing whether a chemical is ahuman carcinogen can be more difficult to achieve. Furthermore, humans are exposed to a number of different chemicals in their daily life, and identifying causative effects from one chemical can be very difficult. Therefore, it is wise to practice a caution in the context of uncertainty. It should be noted that many materials can have a deleterious effect on theenvironment and pose health risks throughout their life cycle24. There is an increased awareness surrounding the impact of chemical toxicity and some of this has beenreflected in legislation as well as best practice guidance and policy. In order to meetpolicy commitments set to enhance wellbeing, health and biodiversity, the materialsused in buildings need to minimise the toxic load imposed on constructors, usersand the environment.



5.3.1 Traditional Building Materials

Appropriate selection of materials for use in traditional buildings is a priority. During refurbishment it is paramount to have a full understanding of the properties of the materials being used and the function of any materials being replaced. Traditional materials may not be immediately replaceable with modern materials.Many of the materials used in traditional buildings are hygroscopic (meaning thatthey readily absorb moisture), and wall constructions are moisture transfusive(meaning that they allow moisture to pass through their fabric). This allowedtraditional building to deal with moisture by a combination of absorption and evaporation. It is vital that any materials selected do not compromise the ability of the building todeal with moisture. Maintaining the vapour permeability of traditional materials canbe an important factor in maintaining a healthy indoor environment in traditionalbuildings. Permeability will be undermined by the application of impervious paintsand finishes and many modern materials and finishes are impermeable. Applying such materials and finishes to traditional buildings can compromise the ability of thebuilding to deal with moisture leading to problems associated with high relativehumidity, including mould growth, and in many cases causing significant damage tothe fabric of the building. Hygroscopic, moisture-open materials are infinitelysuperior. Furthermore, studies have shown that materials with hygroscopic properties can be used as moisture buffers to reduce the extremes of internal relative humidity Conclusions Reducing the exposure to certain indoor pollutants can be readily achieved through informed material selection and is an important mitigation strategy in buildings of alleges. Providing adequate ventilation and moisture management is a more complexissue, and requires an informed and individual response. It is particularly importantthat the materials used in traditional buildings do not restrict the moisture balance inthe building, as this could damage the building fabric and create an unhealthy indoor environment.There is a need for traditional buildings to meet modern expectations of energy efficiency and thermal comfort. However, there has been little research into theimpact on health of such measures. Although there are some general rules, eachbuilding and each room needs individual consideration to determine the mostsuitable course of action to ensure that a healthy indoor environment is maintained.Whilst reducing infiltration and the rate of ventilation may help reduce energy bills, if done to the extreme, it may impair the ability of a building to provide adequate fresh air and deal sufficiently with moisture. Further study into this field in Scotland couldhelp to establish the effectiveness of current practices and indicate the measuresand knowledge required to inform on best practice and appropriate resourcesefficiently.

IV. CONCLUSIONS

In general, building age or type will have marginal impact on the occupants'exposure to potential pollutants. More generic factors such as building location, materials, finishes and furnishings, the provision of adequate ventilation, how a building is operated and the state of repair will have more influence.

There is evidence to indicate that there is a greater incidence of damp in traditional buildings. The state of repair will clearly be a factor. Damp also occurs in modern buildings due to poor quality of construction and can occur anywhere due to poorcleaning and maintenance regimes. Condensation can occuranwhere that there is lack of uniformity of surface temperatures. There is the possibility that certain pollutants may accumulate over time, for example, in dust. However, this phenomenon is also not restricted to traditional buildings. Careful consideration needs to be given to aspects of a minority of traditional buildings that can pose significant and severe health risks if disturbed, such as where lead paint is found. This is extensively covered in guidance and legislation. The following section will discuss some of the key areas for consideration in the mitigation of indoor pollution, and summarize the related energy efficiency issues.

Scope for Further Research

This study summarizes the principle issues of importance when considering indoorair quality in traditional buildings. An investigation of existing research has beenconducted and a synopsis of a number of the most relevant publications provided.Much published information on traditional buildings focuses on conservation of thebuilding fabric. There is a lack of published information on the quality of the internalenvironment in traditional dwellings, and in particular, information on the impacts of energy efficiency measures. There is enough evidence to indicate that measuresaimed at increasing energy efficiency could pose a risk to the health of theoccupants and there is a need for further investigation and guidance.A holistic approach is crucial when considering alterations aimed at increasing theenergy efficiency of properties to ensure that the indoor air quality is notcompromised. An integrated approach is required.Research into indoor air quality is challenging as it invariably requires theextrapolation of laboratory test data to real world phenomena. Uncertainties arise when attempting to identify causation within a complex and variable environment.Identifying the impact of indoor pollutants, and the quality of internal environment,on the health of the occupants can be particularly difficult, especially whenconsidering low-level exposure over a number of years. More study into such areas is warranted and it is an issue of concern for all involvedin the design of the built environment. This is particularly relevant prior to embarkingon programmes of work to deliver energy efficiency if potential long term problemsare to be avoided.

The following have been identified as beneficial areas of further study:

1) Investigate all aspects of indoor air quality in traditional buildings in Scotlandthrough a programme of monitoring, and identify exposure compared withmodern building types. Give attention to the concentrations of outdoorpollutants in the indoor environment.
2) Investigate the role of hygroscopic materials and construction in relation toenergy efficiency, comfort, pollution and indoor air quality.
3) Collate information on traditional Scottish building materials with reference totheir impact on indoor air quality and their effectiveness in regulating indoorhumidity.
4) Investigate the role of modern materials that are compatible with traditionalconstruction types.
5) Review typical renovations or remedial works carried out on different typesof traditional buildings in Scotland and quantify the impact on fabric and airquality. Give attention to any energy saving measures adopted andinvestigate the energy efficiency and efficacy of the ventilation strategies adopted.
6) Review traditional methods of ventilation and present case study examplesof modern conversions or renovations where their function has beensuccessfully retained or improved on in an energy efficient manner. Alsoidentify case studies where problems have arisen.
7) Further investigate, document and champion the numerous ways tosignificantly improve energy efficiency including specification of efficientlighting and appliances, domestic hot water management, and occupantguidance.

8) Investigate the fungicidal properties of lime in the context of its continueduse in traditional buildings and highlight any beneficial properties this couldhave for IAQ and health in buildings including microbiological aspects.

BIBLIOGRAPHY

[1] 2004 Asthma Audit, National Asthma CampaignArundel, V., Sterling, E.M., Biggin, J.H., Sterling, T.D., (1986) Indirect Health Effectsof Relative Humidity in Indoor Environments, Environmental Health Perspectives,Vol. 65, pp. 351-361

[2] Baker, P., et alforman., (2007) Investigation of wetting and drying behaviour ofreplica historic wall constructions, Centre for Sustainable Heritage, UCL

[3] Berge, B., (2000) The Ecology of Building Materials, Architectural Press, Oxford

[4] Berry, R.W., Brown, V.M, Coward, S.K.D, Crump, D.R., Gavin, M., Grimes, C.P.,

[5] Blades, N., Oreszczyn, T., Bordass, W., Cassar, M., (2000) Guidelines on pollutioncontrol in heritage buildings, Re:Source – The Council for Museums, Archives andLibraries

[6] Bordass, W., Bemrose, C., (1996) Heating Your Church, 3rd EdCAG Consultants, Energy Action Scotland, (2008) Carbon Countdown for Homes –

[7] Colome, S., McCunney, M.D., Samet, J.M., Swankin, D., Indoor Air Pollution – AnIntroduction for Health Professionals, American Lung Association, EPA, ConsumerProduct Safety Commission, American Medical Association

[8] Coward, S.K.D., Brown, V.M, Crump, D.R., Raw, G.J., Llewellyn, J.W., (2002) IndoorAir Quality in Homes in England – Volatile Organic Compounds, BRECurwell, S., R., March, C., G., (1986) Hazardous Building Materials – A Guide to theSelection of Alternatives, E. & F.N. Spon, London