Indoor Air Pollution, Passive Ventilation Strategies and Thermal Comfort in Nepal

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Imagine a house situated on 2 600 meters above sea level in the Himalayan mountain range. It is in the middle of January and – 2 ^{o}C inside. The only source of additional heat you have access to is lighting an open fire or firing in the cooking stove, both of which you fuel with some kind of solid biomass such as wood or agricultural waste. The fire is intensifying, you begin to feel the radiant heat and at the same time, smoke is accumulating indoors. What would you do? Do you open a window? Or do you prioritize keeping warm at present versus long term health impacts resulting from exposure to toxic levels of airborne pollutants?

Indoor Air Pollution (IAP) generated by indoor burning of solid biomass fuels in poorly ventilated kitchens is a severe environmental health risk in Nepal as well as in other parts of the world where energy poverty is prevalent. Passive ventilation strategies, i.e. taking advantage of natural driving forces to induce airflow rates through the building envelope, has been suggested as crucial in reducing IAP levels below safe limits. Nonetheless, residents in high altitude settlements in the Himalayan region are exposed to extreme cold climatic conditions and have been reported to live far below comfort standards as internationally would be recognized as acceptable. The employment of natural ventilation thus risk to be restricted by both behavioral practices as well as climate responsive design in vernacular architecture aiming to minimize heat losses.

As a spin-off from a larger study aiming to assess thermal comfort in Nepalese residential buildings, conducted parallel to the EU-initiated CIMCEB collaboration on energy efficient building, this study provides an investigation of stove usage and ventilation patterns and how the employment of different passive ventilation strategies affect the resulting concentrations of IAP as well as impact indoor operative temperatures in Nepalese high altitude settlements. The overall purpose of this thesis is to establish a link between architecture, passive ventilation, IAP and thermal comfort, evaluated in a holistic perspective of the importance of energy efficient building and a sustainable energy supply.

Based on a case study the high altitude settlement of Chame, Manang, an interdisciplinary four-step research process was conducted where carbon monoxide (CO) levels were estimated and operative temperatures simulated for hypothetical kitchens with different opening configurations, where input parameters to the largest extent possible were based on empirically derived data. The results suggest that indoor concentrations of CO in high altitude settlements with similar architectonic features, stove usage and ventilation practices as assessed in this study risk to exceed health deteriorating limits. It is however shown that increasing natural ventilation by only intervening in the building structures applying different opening designs has the potential to enhance ventilation efficiency and thereby reduce CO levels significantly. However, passive ventilation strategies ensuring a healthy indoor air quality is balanced against a 6 % higher annual frequency of hours with indoor operative temperatures falling below 10 ^{o}C.

Understanding the inverse correlation between passive ventilation, thermal comfort and health hence becomes of great concern in the development of a new Nepalese building standard, initiated by the government in the wake of the devastating earthquake 2015. If energy poverty prevails and access to and successful implementation of cleaner cooking technologies do not emerge simultaneously, this study aims to stress the importance of integrating a thorough consideration for the design and application of opening configurations allowing for sufficient natural ventilation in standardized building codes. This insight further indicates the necessity of having a holistic approach when aiming to improve living conditions within the built environment for biomass reliant households in high altitude regions.