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A review on interactions between energy performance of the buildings, outdoor air pollution and the indoor air quality

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Abstract

Indoor air quality has received much attention in recent years because of its rising pollution levels, leading to significant health problems. Indoor air quality has become an important issue because technology development of thermal windows and buildings which have become more energy efficient, leads to sealed buildings, which can greatly increase concentration of pollutants thus presenting high risks to health. In this sense, there is more research focused on assessing human health effects due to exposure to different levels of pollution. This is particularly important as people spend on average 80−90 % of their time indoors.
Reducing energy demand for heating and cooling is essential for improving the energy efficiency of a building, but modern technology re-circulates the air instead of refreshing it leads to reduced air quality.
The paper attempts to provide an understanding of how contaminants, increased population density in cities, the use of new synthetic materials and traffic pollution contribute and interact to increase adverse effects on humans and deteriorate indoor air quality.

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Keywords: indoor air quality; indoor air pollution; outdoor air pollution; building energy performance; pollutants; traffic pollution; PM_{10}; NO_2; volatile organic compounds; health effects

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1. Introduction

It is estimated that the urban population spends a majority of their time up to 90 % in indoor environments and that a large proportion of the time awake is spent in the work place. As newly constructed or retrofitted building infrastructure is increasingly air tight to save energy, the exposure assessment to air pollutants of indoor and outdoor origin is crucial, because they have been linked to various adverse health effects [1–4]

Thus, although the pollutant emission from the indoor sources, is often related to cooking and heating, and is a major anthropogenic source of the air pollution, have been discovered that hundreds of other pollutant species increase health risk. At present, pollutants that represent the most important indoor air quality issue are $PM_{2.5}$, CO, SO_2, NO_x, NH_3, PAHs, and VOCs [5, 6].

As the energy performance of the building improves due to the new regulations that require buildings to be more tightness, it has an inevitable impact on indoor air quality [7, 8]. Ventilation standards recommend higher ventilation rates to improve indoor air quality, but these systems should also become more effective in removing contaminants from the air and from the outdoor air introduced into the building [9–15].

2. Sources of indoor air pollution

In the last 30 years, many research has been done to try to understand the interaction between the different parameters that have an impact on indoor air quality but no analysis has been made that studies the dependence of indoor air quality on energy use and energy efficiency of buildings, indoor pollutants and outdoor air quality [16–19].

Inadequate ventilation is a primary cause of indoor air pollution and is why pollutants rise in homes during the winter [20]. In highly urbanized and industrial areas, lack of air conditioning and high levels of humidity can increase concentrations of pollutants inside.

Other sources include gases from cooking and heating, chemicals from candles and household cleansers, mold and mildew and a host of toxins from building materials [21].

In recent years has observed a pronounced outdoor air pollution in urban area and people tend to believe that they are safe inside of buildings and the air they breathe is cleaner [22, 23]. But the Environmental Protection Agency (EPA) says that the air inside homes and other buildings is more polluted than outdoor air and can cause major health problems [24].

Indoor use of pesticides, cleansers, paints and varnishes and air fresheners, distribute toxins throughout the home. Although some indoor air pollutants are present for years, they were lower in concentration due to dilution with outside air infiltration into the house, but more energy-efficient house today do not allow outside air to infiltrate [25].

Indoor air pollution can cause health problems and prematurely deaths due to pneumonia, stroke, ischemic heart disease, chronic obstructive pulmonary disease and from lung cancer.

The symptoms which may are a sign of indoor air pollution include: unusual odors, stale or stuffy air, lack of air movement, dirty or faulty central heating or air conditioning, excessive humidity, molds, health reaction after remodeling or feeling healthier outside the home.

3. The impact of pollutants on indoor air quality

The most studied indoor air pollutants due to their high impact on health are: formaldehyde, volatile organic compounds, tobacco smoke, nitrogen dioxide, carbon monoxide, particulate matter, radon and biological agents.

Exposure to nitrogen dioxide and carbon monoxide is mainly from cooking, but this exposure can be accentuated by the vicinity of traffic sources [26].

In China, the main indoor air pollutants are CO, $PM_{2.5}$, black carbon (BC) and polycyclic aromatic hydrocarbons, due to the use of coal and biomass for cooking and heating, observing an increase of these emissions during the winter [27, 28].

Studies on the association between respiratory health and exposure to indoor air pollution were based on the measurement of the following parameters: PM, VOCs, bacteria, mold, CO_2, temperature and relative humidity. All these parameters exhibited seasonal and spatial variations with higher levels of VOCs, CO_2 and PM in winter, and an increase in bacteria and mold concentration in the summer [29].