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AN EXAMINATION OF SOURCES OF INDOOR AIR CONTAMINANTS IN THE STUDENTS' HOSTEL ROOMS IN NNAMDI AZIKIWE UNIVERSITY, AWKA-ANAMBRA STATE

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Abstract

The quality of indoor air in university hostels plays a pivotal role in the health and well-being of students. Poor indoor air quality (IAQ) can lead to various health issues, including respiratory problems, allergies, and hindered cognitive functions, ultimately affecting academic performance. This study examines IAQ in university hostels, focusing on a case study of Nnamdi Azikiwe University, Awka-Anambra State, Nigeria. A comprehensive examination was conducted using a checklist developed through a pilot survey of the study area. The checklists considered such things as cleaning routines, the presence of offensive odors, and sources of indoor air contaminants in the hostels. The collected data were analyzed using a simple pen and paper as a tool. The findings revealed that particle sources were a significant issue and emphasize the need for improved ventilation, proper waste disposal, and maintenance practices. The study underscores the importance of addressing IAQ in hostels to promote students' well-being, comfort, and academic success.

Keywords: Academic Performance, Contaminants, Indoor Air Quality (IAQ), Students Hostels, Ventilation Systems

Introduction

The quality of indoor air significantly impacts the health and performance of occupants. Quarcoo *et al.* (2012) Indoor air quality is especially crucial for students residing in hostels, where overcrowding and limited ventilation can lead to poor IAQ, overheating, and increased exposure to contaminants (Smith and Johnson, 2019). A study by American Association of Heating, Refrigerating, and Air-Conditioning Engineers (AAHRAE). (2020) shows that schools and their properties are poorly equipped or in poor physical condition, with heating, ventilation, and air conditioning (HVAC) systems having the least importance. Similarly, in a paper titled "Indoor air quality at school and students' performance: recommendations of the UNESCO Chair on Health Education and Sustainable Development and the Italian Society of Environmental Medicine (SIMA)," researched by Pulimeno *et al.* (2020), it was stated that the basic factors determining a healthy or unhealthy microclimate at school are ventilation, temperature, and humidity rate.

Although research dealing with hostels' air quality is scarce in the literature, a few such studies have been carried out in different parts of the world, which indicate a serious indoor air quality problem, particularly in developing countries (Zhao, Li, Gao, Tao and Shen, 2014). The deteriorated air quality in areas surrounding the hostel is an additional challenge, as there are no exhaust chimneys

in the hostel's kitchen, and faulty mechanical means of ventilation like a ceiling fan are typically not equipped with any pollution control devices such as air purifiers, air conditioners, catalysts, or condensers (Juntarawijit and Juntarawijit (2017).

Many students in public places like hostels are subjected to effects like dizziness, sweating, headaches, coughing, drowsiness, and general discomfort due to the nature of the activities taking place, such as cooking, rowdiness, and the tightness of the building (Joana 2012). Thus, polluted hostels or classrooms may increase the chance of short- and long-term health problems for students and staff, reducing teachers' productivity and students learning possibilities. Kim *et al*. (2005) stated that long exposure to a polluted indoor environment may cause headaches, dizziness, nausea, fatigue, and dry skin.

More so, that indoor air quality level may be 2–5 times and occasionally hundreds of times higher than the outdoor levels, with the activities of people living in the building, such as the use of kerosene and gas stoves, fuel combustion, tobacco smoking, etc., being the main factors that cause the presence of air pollutants that result in poor indoor environment quality (Desalu, Adekoya and Ampitan, 2010). As studied by Pulimeno *et al*. (2020), when this limit is exceeded, the air becomes stagnant, which can cause headaches, tachycardia, nausea, memory disturbances, lack of concentration, blurred vision, sweating, restlessness, vomiting, flushed skin, and other anthropogenic activities that emit gases like nitrogen oxide (NO2). CO2 can also be produced outside the hostels, as it's routinely produced by the combustion of fossil fuels. However, the importance of maintaining optimal indoor air quality (IAQ) in such environments is often underestimated.

Hostels in Unizik are faced with inadequate ventilation systems. Improper openings for ventilation in the hostels can also promote the accumulation and concentration of pollutants in the indoor air, which pose serious health problems. This can have an effect on students and their performance but also result in poor financing by the government as a result of their absences. This knowledge of good air quality is useful in determining how effectively and efficiently the students become aware of their immediate surroundings, deviate from activities that will have adverse effects on the environment, improve their academic standings, and live a healthy life.

This article delves into a comprehensive examination aimed at understanding the sources of indoor air contaminants within university hostel rooms, focusing on the Nnamdi Azikiwe University, Awka-Anambra State, with a view to suggesting areas for improvement.

Review of Related Literature

Indoor air quality has gained prominence in recent years due to its profound impact on human health and productivity (Wang and Brown, 2018). According to Thompson and Davis (2016), students, in particular, are a vulnerable group as they spend a significant portion of their time indoors, especially within hostel accommodations. Poor indoor air quality can lead to various health issues, including respiratory problems, allergies, and even hindered cognitive functions.

University hostels present a unique set of challenges for maintaining high indoor air quality. Moreover, suboptimal IAQ can result in discomfort, reduced concentration, and an overall decline in the quality of life. Recognizing the role of IAQ in the lives of students is imperative for ensuring their well-being and academic success (Gupta and Patel, 2014). The American Society of Heating, Refrigerating, and Air-Conditioning Engineers defines acceptable indoor air quality (IAQ) as "air in which there are no known contaminants or harmful concentrations (ASHRAE, 2010). According to Joy and Joshua (2017), student or academic performance is defined as the degree to which students surpass in their various academic pursuits or registered

programs. It is also a representation of outcomes, showing the extent to which a person or student has obtained specific goals that were the focus of activities in instructional environments. (Steinmayr *et al.*, 2015). Indoor air quality is a major contributor to the quality of students' lives and is affected by the presence of many pollutants related to building materials, furnishings, and human activities (EPA, 2017). Overcrowding is a prevalent issue where rooms designed for a certain number of occupants end up accommodating more individuals, leading to compromised ventilation and an increased potential for contaminants to accumulate (Adams and White, 2015).

In Nigeria, the research carried out by Ezeokoli *et al*. (2020) found out that IEQ parameters of hostels are: indoor air quality, which was poor due to inadequate ventilation of rooms; thermal comfort of rooms, which was found to be warm; indoor light quality, which was good; and acoustic comfort and noise, which were slightly good and to some extent, poor. The research recommended that all the parameters be considered, especially the provision of two sizeable windows for cross ventilation in the hostels. Also, Nnadozie, Njoku, Onu, and Anyanwu (2017) found that the major air pollutants in the hostels at the Federal University of Technology Owerri were sulfur dioxide, carbon monoxide, and particulate matter. These pollutants were found to have a toll on the health, wellbeing, and productivity of students (occupants). Similarly, a studied by the Environmental Protection Agency (EPA) (2003) found that poor air quality affects students' performance in a range of ways, ranging from illness to absenteeism and health challenges, causing a reduction or lack of mental concentration, calculation, or memory loss. Also, students who are exposed to air pollutants, noise, light, and thermal comfort are at risk of adverse health effects and discomfort that cause absenteeism, leading to a decrease in productivity and performance (EPA 2003). However, to improve IAQ and performance in students, Polidori *et al.* (2013) showed that high-performance filter systems for air conditioners integrated with air purifiers can generate a reduction of 90%–96% in the concentrations of particulate matter (PM1, PM2.5, and PM10) and also carbon particles. Also, the health of students can be improved by reducing incidences of asthma from 16% to 13% in the classrooms (Martenies and Batterman, 2018). Likewise, Raysoni (2011) revealed that outdoor air quality levels can significantly affect indoor air quality, especially when hostel buildings are close to a major highway, road, or industrial area, thereby increasing the indoor pollutant concentration level.

Mendell's (2005) on the other hand reviewed the occupants' health and performance in schools outlined that schools and other kinds of buildings related to schools are likely to have conservational deficiencies as a result of shortages in funding, inadequate operation and maintenance of facilities, tight budgets, and often their mechanical equipment does not suitably accommodate the facility needs of each room based upon the occupancy and activity level inside, in addition to facilities in hostels. To improve the air quality factors, ventilation is a necessity that could worsen or improve the air quality by reducing the concentration level of air pollution.

The significance of acceptable indoor air quality cannot be overstated. It affects academic performance, well-being, and overall quality of life. Common indoor air pollutants, such as volatile organic compounds (VOCs), formaldehyde, carbon dioxide (CO2), carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and particulate matter, pose various health risks. Each pollutant stems from different sources, including combustion processes, building materials, consumer products, and even human activities.

Common indoor air pollutants in hostels

A summary of some sources of indoor air pollutants based on the findings from the

research by Zhang and Smith (2003) includes the respective pollutants. The sources consist of combustion and burning of solid fuel indoors, tobacco smoking, and outdoor air pollutants; emissions from construction materials and furnishings; and improper maintenance of ventilation and air conditioning systems, which emit pollutants such as asbestos, volatile organic compounds, formaldehyde, and biological pollutants. This inability of the building to extract indoor air has caused increases in the levels of indoor pollutants (Zhang and Smith, 2003). Furthermore, even those considered minor pollution sources (e.g., furnishings and household materials) increase the chance of indoor air pollution exposure as well as the increased risks of health illnesses for the occupants.

Table 1: Outline of the number of indoor air contaminants and their sources.

Sources	Main pollutants
Outdoor air	So_2, No_2, Particulate Matter, Biological Particulates, Benzene
Combustion of fuel	Co, No, VOCs, Particulate Matters
Tobacco smoke	Co, No, VOCs, Particulate Matters
People	Co_2, Organic Compounds
Building materials	VOCs, Formaldehyde, Radon, Fibre, Other Particulates, Ammonia
Consumer products	VOCs, Formaldehyde, Pesticides
Furnishings	VOCs, Formaldehyde
Office equipment including HVAC	VOCs, Ozone, Particulates
Bacteria and fungi	VOCs, Biological Particulates
Contaminated land	Methane, VOCs, Contaminated Dusts (E.g. Metals)
Ground	Radon, Moisture
Washing and cleaning	Moisture
Animals (e.g. mites, cats)	Allergies

Source: Crump, Dengel and swainson (2009)

In another study, it was found that exposure to certain pollutants may cause a variety of effects, ranging in severity from the perception of unwanted odors to unwanted growth (Jacob Kelly and Sobolewski, 2007). Jacob *et al.* (2007) define contaminants as chemical, physical, or biological contaminants in the breathable air inside a habitable structure or conveyance, including workplaces, schools, offices, homes, hostels, and vehicles. Examples of health effects are the dispersal of airborne infectious disease, microorganisms in air humidifiers causing pneumonia and humidifier fever, mold increasing the risk of allergy, and an increased risk of lung cancer through exposure to Environmental Tobacco Smoke (ETS) and radon (ASHRAE, 2010).

Table 1 shows an outline of the number of indoor air contaminants and their sources.

Descriptions of common indoor air contaminants

1. **Volatile organic compounds (VOCs):** VOCs emit from construction and furnishing products and have the potential to cause poor air quality over a period of weeks or years. VOCs are released from consumer products, including electrical goods such as computers and printers, as well as cleaning products and air fresheners (Government of Hong Kong, 2003). Emission rates should not result in indoor concentration levels greater than 0.5 mg/m3 of total VOCs (Texas IAQ Guidelines, 2002), 0.2 mg/m3, or 0.6 mg/m3. Eye, nose, and throat irritation; headaches; loss of coordination; nausea; and damage to the liver, kidneys, and central nervous system can be a result of VOCs. A few VOCs have been linked to cancer in humans (e.g. benzene) (Daisy, Angell and Apte, 2003).

2. **Formaldehyde**: This is a colorless gas with a strong odor and is a very volatile organic compound (VVOC) that has been widely studied because of its release from a range of building and consumer products. It is most commonly found in various products, such as insulation products, ceiling tiles, particle board, plywood, office furniture, and many others. Studies have shown that formaldehyde levels should not exceed 0.1 mg/m3, 0.03 mg/m3, 30.75 ppm, 2 ppm (15 min), 0.3 ppm, and 1 ppm because even low levels may lead to an increased risk of

sensitization to allergens. (Sahar, 2014; Daisey *et al.*, 2003) mentioned that exposures to VOCs, mold, and microbes are generally related to asthma, SBS, and other respiratory symptoms.

3. **Carbon dioxide (CO2)** is a natural constituent of air, and only in exceptional circumstances is it present in sufficient amounts to be a danger to health. It can be present in buildings as a result of the respiration of people and animals, as a product of combustion, or as a component of soil gas. It is widely used as an indicator of ventilation rate and, effectively, as a substitute for body odor. Acceptable CO2 levels should not exceed 1000 ppm, 5000 ppm, or 10,000 ppm (1 hour). When this limit is increased, air becomes stagnant and could cause headaches, tachycardia, nausea, memory disturbances, SBS, lack of concentration, blurred vision, sweating, restlessness, vomiting, flushed skin, and even panic attacks (Oliveira *et al.*, 2019; Daisy *et al.*, 2003).

4. **Carbon monoxide (CO)** is a colorless, odorless gas produced by the incomplete combustion of most materials containing carbon. Incomplete combustion can occur, e.g., when there is inadequate ventilation in an appliance, automobile exhaust, parking garages, etc. The CO rates should be 9 ppm, 35 ppm (1 h), 50 ppm, 30 ppm, and 60 ppm (30 min), and 10 ppm (11.4 ug/m3) and 20 ppm (22.8 ug/m3). According to Currie *et al.* (2009), high concentrations are fatal, moderate concentrations reduce brain function, and low levels cause dizziness, tiredness, and nausea.

5. **Nitrogen dioxide (NO2)** is emitted from gas-fueled cookers, fires, water heaters, and oil-fired space heaters. According to the ASHRAE (2010) harmonized regulations, NO_2 should not exceed 0.05 ppm (1 year), 5 ppm, 5 ppm, 10 ppm (5 min), and 0.04 ppm–0.06 ppm (75.0 ug/m3–113 ug/m3), respectively.

6. **Sulfur dioxide (SO_2)** is produced by burning sulfur-containing fuels such as coal and oil. SO_2 should be within 0.03 ppm (1 year), 0.14 ppm (24 h), 5 ppm, 0.5 ppm, and 1 ppm; it should also be within 0.01 ppm (26 ug/m3) and 0.1 ppm (26 ug/m3).

7. **Particle pollution, or matter** refers to a mix of very tiny solid and liquid particles that are found in the air, both indoors and outdoors, and which can be harmful to health. It is difficult to assess particle pollution because the particles themselves are different sizes; some are one-tenth the diameter of a strand of hair. Many are even tinier; some are so small they cannot be seen with eyes except with an electron microscope. The particle sizes are grouped according to coarse, fine, and ultrafine. Coarse particles fall between 2.5 microns and 10 microns in diameter and are called PM10–2.5. Fine particles are 2.5 microns in diameter or smaller and are called PM2.5. Ultrafine particles are smaller than 0.1 micron in diameter and are small enough to pass through the lung tissue into the blood stream. (Al-Salem and Khan, 2010).

Sources of Indoor Air Pollutants in Hostels

Indoor environments can harbor various sources of air pollution. These pollutants originate from different places, including combustion processes (which release harmful gases and airborne particles of varying sizes), building materials (which emit airborne particles and release gases), and furnishings (which release gases). Sources of combustion pollutants encompass oil, gas, kerosene, coal, wood, and tobacco products. Building materials and furnishings exhibit a wide range of diversity. For instance, materials like asbestos insulation, damp carpets, cabinets, and furniture constructed from certain types of pressed wood all represent examples of sources that emit pollutants (Bake, 2013). Household cleaning products, maintenance chemicals, and personal care items have the potential to introduce pollutants into the indoor air. These contaminants can have a detrimental effect on indoor air quality and pose health risks to those residing in the space (Omole *et al.*, 2020). There are examples of common indoor

air contaminants that might be present in university hostels:

i. **Biological Sources:** These include mold, mildew, bacteria, and viruses. They can thrive in damp or humid environments, such as bathrooms and kitchens. Mold grows in the dark and humid areas around the house. Mold can trigger an allergic reaction in some people, including eye or throat irritation, coughing, and headaches. Pets are a major source of indoor air pollutants (EPA, 2015). Dampness in buildings can lead to mold growth, which can release spores and mycotoxins into the air. Mold can be a significant indoor air quality concern, especially in areas prone to moisture issues.

ii. **Chemical Sources:** These sources encompass emissions from items utilized within the building, like office equipment, furniture, wall and floor materials, pesticides, and cleaning products. They can also result from unintentional chemical spills as well as from products used during construction, such as adhesives and paints. Additionally, gases like carbon monoxide, formaldehyde, and nitrogen dioxide, which are by-products of combustion, contribute to these chemical pollutants (OSHA, 2011).

iii. **Particle (Non-biological) Sources:** Particles refer to non-biological solid or liquid substances that possess a low enough weight to remain suspended in the air. These particles can enter the building from external sources, including dust and dirt from the outdoors. In a university hostel, dust can accumulate on surfaces, leading to reduced air quality. Additionally, cooking in shared hostel kitchens can release pollutants like particulate matter, grease particles, and cooking odors into the air. Occupant activities, such as personal hygiene, can introduce contaminants like aerosolized toiletry products and hair sprays into the indoor environment (OSHA, 2011).

Methodology

In order to achieve the research objective effectively, we conducted a thorough review of relevant literature and developed a checklist using a pilot study. This review encompassed a wide spectrum of sources, including online materials, textbooks, academic journals, and both published and unpublished theses. Our goal was to create a comprehensive knowledge base by carefully examining various literary sources.

To examine indoor air quality in university hostels, a comprehensive approach was taken. A well-structured checklist was employed to collect data on various factors affecting IAQ. The main campus is comprised of a total of six blocks of hostels with 1652 rooms, which covers the population size of the study. The hostels have kitchens on each floor; all toilets are suites, and other facilities like a salon, canteen, common rooms, doors and windows as openings, as well as sources of ventilation including ceiling fans. The hostel block was randomly sampled and named anonymously. The foregoing information is contained in Table 2.

Table 2: Information about the Hostels studied

S/n	Hostel	Gender (Male/Female)	No of floors	Bed spaces	Number of rooms	Number of Occupants	No of rooms per floor	Kitchen
1	A	M	3	4	341	1364	113	3
2	B	M	3	4	341	1364	113	3
3	C	F	3	4	341	1364	113	3
4	D	F	3	4	341	1364	113	3
5	E	F	4	3	144	432	36	4
6	F	F	4	3	144	432	36	4
Total					1652	6320		

Source: Field Survey (2022)

Awka has a warm-humid climate characterized by two main seasons (dry and rainy). It experiences constant high temperatures and high relative humidity with low wind speeds throughout the year. The temperature ranges from 23–27 °C, with a maximum value of 30-34°C and a mean relative humidity value of 84%. The rainy season lasts from April to November, and the dry season is from November to March. The people of Awka are known for their entrepreneurial skills and businesses; these skills are also found among the students.

The following information formed the basic information: cleaning routines (which indicate how often the hostels are cleaned), presence of offensive odors (if there are foul smells in and around the hostel buildings), and sources of pollutants (which were grouped into chemical sources, biological sources, and particle sources). Each hostel block was visited at 7:00 a.m. The facilities of each hostel were checked, ranging from the windows being closed or open, the types of exhaust fans, the number of air conditioners, the average occupancy, and the floor materials. The study was conducted at Nnamdi Azikiwe University's Awka main campus, focusing on multiple hostel blocks. Interpretations of data collected from checklists were analyzed using a simple pen and paper formatted in yes/no answers. Attached on the last page is the checklist used and the population size.

Result and Discussion

From the checklist carried out, it was observed that in Hostels A and B, there is a presence of biological and particle sources of indoor air pollutants, despite cleaning routines during normal working hours. In Hostels C and D, offensive odors are reported, but there are no identified sources of chemical or biological pollutants. Hostels E and F maintain a constant cleaning routine, and although there are no offensive odors, particle sources contribute to indoor air quality concerns in these hostels. Hostel A cleaning routines occur during normal working hours from 7:00 a.m. to 4:00 p.m. There were no reported offensive odors in the hostel.

There are no identified chemical sources of indoor air pollutants. Biological sources of indoor air pollutants were found to be present, and there were particle sources contributing to indoor air quality. Hostel B Cleaning also occurs during normal working hours, from 7:00 a.m. to 4:00 p.m. Similar to Hostel A, there are no reported offensive odors in Hostel B. There are no identified chemical sources of indoor air pollutants. Biological and particle sources of indoor air pollutants were also present, contributing to indoor air quality problems. Cleaning occurs during normal working hours from 7:00 a.m. to 4:00 p.m. The presence of offensive odors was found in Hostel C. There are no identified chemical sources of indoor air pollutants. There are no identified biological sources of indoor air pollutants. Particle sources were observed to be present. For Hostel D, cleaning and sanitation also occur during normal working hours, from 7:00 a.m. to 4:00 p.m. Similar to Hostel C, there was a reported presence of an offensive odor in Hostel D.

Chemical sources and biological sources were not the presence of particles was noticed.

Hostel E and Hostel F differ in their cleaning routines, with staff constantly cleaning the hostel. The presence of offensive odors was not reported in both hostels. There were no identifications of chemical sources or biological sources, but particle sources were noticed (Table 3).

The results can be attributed to a study carried out by Annesi-Maesano *et al.*, (2013) on the adverse respiratory health effects of air pollutants related to IAQ and buildings. The researchers ascertained that IAQ problems are a result of poor building construction and maintenance, poor cleaning, and poor ventilation.

The analysis revealed that particle sources were the primary indoor air pollutants within the studied hostels. This is also attributed to deteriorating building materials and inadequate ventilation. The frequent opening of doors and windows allowed outdoor air, dust, smoke, and insects to enter the rooms, contributing to particle pollution as documented by the EPA in 2015.

Table 3 shows the types and sources of indoor air pollutants within the hostels.

Table 3: Sources of Indoor air pollutants within the Hostels

Hostels	Cleaning routines	Presence of offensive odor	Chemical sources	Biological sources	Particle sources
Hostels A	Normal working hours 7:00 am – 4:00 pm	No	No	Yes	Yes
Hostels B	Normal working hours 7:00 am – 4:00 pm	No	No	Yes	Yes
Hostels C	Normal working hours 7:00 am – 4:00 pm	Yes	No	No	Yes
Hostels D	Normal working hours 7:00 am – 4:00 pm	Yes	No	No	Yes
Hostels E	Constantly having staff cleaning the hostel	No	No	No	Yes
Hostels F	Constantly having staff cleaning the hostel	No	No	No	Yes

Source: Field Survey (2022)

Conclusion

This study underscores the significance of addressing indoor air quality and contaminants in university hostels. From the results, particle sources emerged as a prominent issue in all hostels despite the routines constantly carried out by workers. There is a need to emphasize that improved ventilation, proper sanitation, proper disposal of waste around hostels, and maintenance practices should be adhered to in order to ensure a healthier indoor environment that can positively impact students' overall well-being, health, and academic performance.

Based on the research findings, it is recommended that the university administration take proactive measures to enhance living conditions and provide comfort to occupants within the hostels. This could involve improving ventilation systems, disposing of waste, repairing deteriorating materials, and promoting awareness among students about the importance of maintaining a healthy indoor environment.

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Appendix: Checklist

Section A: Condition of Space

1. Window opened? Yes___, No___

2. Presence of Exhaust fans? Yes___, No___, Type of Exhaust fan present? Mechanical _____, Natural _____,

3. Presence of Air conditioning system? Yes___, No___, Number of ACs_____

4. Type of ventilation present? Room with open windows ___, Room with open doors___, Room with both open doors and windows___, Mechanical___

5. Average occupancy_____

6. Floor materials? Concrete Screed____, Tiles____, Carpet____, Rug___, Timber___, Brick___

S/N	Chemical Sources	YES	NO	Remarks
1	Do you use electric or gas stove or kerosene stove cooking?			
2	Are moisture-producing appliances, such as stoves or dishwashers, properly vented?			
3	Do you see or smell or perceive offensive odor within the hostel environment?			
4	Have pesticides been improperly applied?			
S/N	**Biological Sources**	**YES**	**NO**	**Remarks**
1	signs of mold growth			
2	Cockroaches and/ or rodents (such as droppings or dead specimens in traps)?			
3	Food crumbs or open or unsealed food?			
4	Water damage, moisture, or leaks (such as damp carpet or leaky plumbing)			
5	trash properly disposed on daily			
S/N	**Particle (Non-biological)**	**YES**	**NO**	**Remarks**
1	Would you describe your hostel as unusually dusty?			
2	Is dust or dirt staining walls, ceilings, furniture or draperies?			
3	Do occupants have hobbies that create dust or dirts?			
4	Is floor covering present?			