

The Elements of an Indoor Air Quality Policy and Management Plan for Nursery Schools

Craig Harlequin^{1*}, Nasrudeen Ally² and Ameera Fatema Wajidally³

¹Department of Environment, University of Guyana, Aurora Gold Mine, Georgetown, Guyana

²Department of Environment, University of Guyana, Guyana Geology and Mines Commission, Georgetown, Guyana

³Department of Biology, University of Guyana, Greater Georgetown, Guyana

Abstract

School authorities are expected to provide healthy indoor environments for children. However, managing Indoor Air Quality (IAQ) is a challenge resulting in unhealthy school environment. The IAQ in two nursery schools located in Georgetown was at an unacceptable level due to high particulate matter (PM_{2.5}), airborne bacteria and fungi. It was revealed through discussions with Ministry of Education officials that an IAQ management plan does not exist. Therefore, this study was undertaken to determine the components of an IAQ management plan and policy, as well as global guidelines. A qualitative design was used employing secondary data and interviews as the data collection instruments. The data obtained was used to construct an IAQ management plan for nursery schools. In Guyana, there are no guidelines for IAQ. As a result, the WHO threshold limits for nitrogen dioxide, carbon monoxide, sulphur dioxide, particulate matter and airborne microorganisms were recommended. Exposure to pollutants above the threshold limit can cause severe health implications in children such as cardiovascular and respiratory diseases. The objectives of this paper focused on determining the global guidelines for indoor air quality in schools, the elements of an indoor air quality policy for nursery schools and the elements of an indoor air quality management plan for nursery school. The interviews revealed the components of the IAQ policies should include definition of terms, objectives, guiding principles, applicability, policy outcomes and responsibilities, areas of concern, enforcement and annual review. The results indicated an IAQ management plan can be derived from the IAQ policy.

Keywords: Indoor air quality • Management plan • Policy • Nursery schools

Introduction

Indoor Air Quality (IAQ) in schools has gained special attention because children spend a substantial percentage of their time indoors at school. As a result, school officials are expected to create an ideal learning environment for children [1] good IAQ is important because it improves students' learning abilities and health as well as their productivity and efficiency [1] Despite its importance, good IAQ appears to be a difficult standard to achieve. In India, approximately 100,000 children under the age of five died as a result of health complications linked to poor IAQ in 2016 [2].

Poor IAQ in schools can be caused or exacerbated by a number of factors. These include overcrowding, inadequate ventilation, increased use of cleaning chemicals, poor building construction and maintenance, high levels of biological and chemical contaminants (Environmental Law Institute, 2002). Children who are exposed to these environmental problems are more likely to develop asthma, allergies and increased rates of infectious diseases, headaches, chronic sinusitis and a variety of respiratory diseases (Environmental Law Institute, 2002). They are particularly vulnerable to air pollution because their respiratory and immune systems are underdeveloped and because they are constantly active, they breathe a higher volume of air relative to their body weight [3]. Approximately 1.1 million children in the United Kingdom suffer from asthma symptoms and there is always an increase in

hospital admissions in September, which coincides closely with their return to the indoor school environment [4].

Due to the numerous negative consequences of poor IAQ, several agencies and organizations such as the American Society of Heating, Refrigerating and Air- Conditioning Engineers (ASHRAE), the World Health Organization (WHO) and the United States Environmental Protection Agency (U.S. EPA) developed permissible limits for common indoor air pollutants such as Carbon Dioxide (CO₂), Nitrogen Dioxide (NO₂), Sulphur Dioxide (SO₂), Carbon Monoxide (CO), Particulate Matter (PM_{2.5} and PM₁₀) and airborne microorganisms. These guidelines are intended for public health professionals who are responsible for preventing health hazards associated with environmental exposures and authorities involved in indoor materials, products, design and use of buildings. In addition, the US EPA, 2009, outlined key areas to which new and existing schools must adhere. For Year 1 and 2 students, the ratio of children to adults should not exceed 10/15:1, drains and garbage bins should be covered and located at least 100ft from the building, classrooms should be adequately ventilated, schools should be located away from potential sources of air contaminants and an annual monitoring campaign should be held to assess average indoor concentrations of pollutants such as airborne microorganisms and particulate matter (PM_{2.5} and PM₁₀).

In addition, several schools design and implement IAQ policies. This policy establishes a framework for preventing and resolving IAQ issues such as overcrowding, traffic conditions and pest infestations. The policy comprises of important elements such as objectives, scope, individual responsibilities and the concerns to be addressed [5].

Similarly, school officials have also devised and implemented IAQ management plans that are specific to their needs. The IAQ management plan supports the policy by offering a range of flexible and specified measures for mitigating IAQ problems [6]. In the United States, 50% of the schools have well-designed IAQ management plans in place to protect building occupants' health and safety while also reducing exposure to indoor air pollutants [7]. According to United States Environmental Protection Agency [6] a crucial aspect of the plan, is the appointment of an IAQ coordinator and the formation of a team to guarantee that appropriate IAQ practices are followed at all stages

***Address for Correspondence:** Craig Harlequin, Department of Environment, University of Guyana, Aurora Gold Mine, Georgetown, Guyana, Tel: +5927014342; E-mail: craigharlequin2727@gmail.com; nasrudeen.ally123@gmail.com

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of school siting, design, building and operation. Due to the complications of defining priorities for repairs and improvements, as well as dedicating resources, it is crucial to maintain strong communication in order to build consensus among school management and all relevant committees and groups [6]. Notably, following the implementation of an IAQ management plan and policy, improvements in either environmental or health outcomes were observed. The relative humidity, carbon dioxide and allergen levels were all improved at several schools in Salt Lake City and Minnesota [5].

Literature Review

Indoor air quality issues

The importance of good IAQ cannot be overstated. As a result, the relevant authorities should ensure the school's indoor environment is conducive to students' and staff's comfort, health and well-being. In light of this, only two studies evaluated the conditions of schools. Toyinbo O [8] employed observational checklists and interviews to assess the condition of Nigerian nursery school buildings and their possible health impacts on students. There was no theoretical framework for this study. However, a total of 15 classrooms from five nursery schools participated in the assessment. The data was organized and analyzed using IBM SPSS statistic 23. Findings from this study revealed that several deplorable conditions had a significant impact on the indoor environmental quality of classrooms. During the walkthrough inspection, Toyinbo O [8] observed inadequate classroom ventilation and congestion contributed to stifling air. There was no floor covering in any of the schools, exposing students to particulate matter, particularly during and after sweeping. Furthermore, the compounds were covered with sand so students could participate in sports and waste was burned regularly on the school grounds. As a result, complaints about air quality were common during incineration and sporting activities. Exposure to these problems has been linked to respiratory infections, headaches and fatigues.

On the other hand, Harlequin, conducted a quantitative study in Guyana to investigate the IAQ in 2 Nursery Schools. One of the objectives was to determine the level of compliance using the Guyana Child Care and Protection Agency (GCPA) and the United States Environmental Protection Agency (U.S. EPA) standards for a safe classroom environment. In this research, no theory was used; instead, Harlequin, framed her discussion around her findings and the guidelines developed by the GCPA and the U.S. EPA. During a walk-through inspection, the researcher utilized observational checklists to assess the level of compliance. Results were analyzed using Excel 2016. The researcher discovered although School A (53.79%) and School B (59.09%) were moderately compliant with the regulations developed by the GCPA and U.S. EPA, their compliance percentage was on the low end of the compliance scale (50-70%). Before developing a plan, it is critical the researcher first discovers the problem. This allows for proper recommendations to be made. Both schools had a moderate level of compliance due to an unnatural accumulation of dirt on the fan blades, open drains and garbage bins at the entrances and windows and no mesh on the windows and doors. These conditions served as breeding grounds for mosquitoes and flies, which were detected in large numbers throughout the school environment. These organisms may carry bacteria and viruses into schools. Furthermore, both schools were overcrowded with high temperature which promotes the growth of airborne bacteria and fungi. Pollutant sources from automobile emissions, open burning and construction activities were located near the schools. As such, outdoor air contaminants may enter the buildings through two routes: open windows and doors.

Global guidelines for indoor air quality in schools

During the last decade, the World Health Organization (WHO), United States Environmental Protection Agency (U.S. EPA) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) have been regularly refining and updating quantitative air quality guidelines in order to fulfill the requirements for IAQ management. The objective of these guidelines is to offer a consistent framework for protecting public health from the adverse effects of poor IAQ, as well as to minimize or eliminate those pollutants that

are known or expected to be hazardous. Chithra VS and Nagendra SMS [9] provided recommended guideline limits for main pollutants such as particulate matter $PM_{2.5}$ and bio aerosols when reviewing and synthesizing scientific research on IAQ in schools. The study highlighted that $PM_{2.5}$ is the deadliest pollutant because it can infiltrate the lung barrier and enter the bloodstream, causing cardiovascular and respiratory illnesses and malignancies. As a result, Chithra VS and Nagendra SMS [9] emphasized that the WHO guideline on yearly average $PM_{2.5}$ concentrations should not exceed $10 \mu g/m^3$, with 24-hour average exposures not exceeding $25 \mu g/m^3$. Furthermore, the WHO guideline values of 500 CFU/ m^3 and 1000 CFU/ m^3 were established to safeguard the public from the health implications of airborne bacteria and fungi respectively. Exposure to high levels of airborne bacteria and fungi can cause symptoms such as rhinitis, headaches, asthma, vomiting, difficulty in concentration and fatigue. On the other hand, Mansour, 2014, conducted a study in the North Texas region to present a series of IAQ guidelines developed by international agencies. From the results, WHO guidelines for Carbon Monoxide (CO) are 10 mg/ m^3 for 8 hrs. and 35 mg/ m^3 for 1 hr. respectively. At low levels, CO exposure symptoms include headaches, fatigue, nausea and high levels can be fatal or significantly increase students' absences.

Elements of an IAQ management policy

The study by Everett Jones S, et al. determined whether schools with a structured Indoor Air Quality (IAQ) management program were more likely to have policies that encourage superior IAQ than schools without a program. Although no theory is used in this article, Everett Jones S, et al. [10] framed their discussion around the IAQ Tools for Schools Framework developed by the U.S. EPA. Questionnaires and computer-assisted personal interviews were used as data collection tools. The participants in the study were principals, assistant principals, administrators and other school staff. Additionally, data from the 2006 Public Health Policies and Programs Report was analyzed. Findings from this study revealed that 51.4% of schools had a policy that promoted good IAQ management. For instance, schools had preventive procedures in place to deal with the moisture problem and accompanying mold issues. Everett Jones S, et al. [10] recognized the importance of policies to minimize exposure to indoor air contaminants.

Elements of an IAQ management plan

Csobod E, et al. [11] conducted a multidisciplinary study to develop guidelines and recommendations on mitigation strategies in the primary and kindergarten school environment. A theory was not used by the researchers; however, to achieve the research objectives, the study was carried out in 23 European countries. Each country provided data from three to six schools, with the schools chosen based on location in rural (low traffic activity) and urban areas (high-medium traffic activity). For each school, the researchers conducted a walk-through inspection to complete their checklists. The findings indicated that IAQ in school buildings was inadequate, which negatively impact building occupants' health, attendance and performance. As a result, procedures for dealing with IAQ issues were developed. These procedures focused on key issues such as location, which entailed proper management of outdoor air pollution and its major sources (e.g., transportation and traffic). Furthermore, Csobod E, et al. [11] emphasized the importance of incorporating procedures for site selection, design and construction (including retrofitting), into the plan in order to avoid or minimize contaminants. This research employed a similar methodology as Csobod E, et al. [11] where the sample population was nursery schools and one of the criteria for selection were their location where one was based on roadways with high traffic activity and the other with low traffic activity.

Similarly, a Polish study published in 2019, sought to develop an IAQ management plan in 12 schools using observational checklists as the data collection instruments [12]. InAirQ, 2019, noted there are no comprehensive legal regulations in the area of IAQ in schools and presently no entity in Poland would oversee IAQ in virtually all types of environments. As a result, school IAQ is poor and buildings are in poor structural condition. InAirQ, 2019, created an action plan that recognized the importance of human resources; therefore, they appointed an IAQ coordinator who also organized a team of various individuals to ensure good practices were followed throughout the school cycle, including

siting, construction and operation. The study recommended adhering to the WHO guideline, if no local guidelines exist. The study also emphasized the significance of increasing awareness among all parties involved and identifying entities responsible for enhancing IAQ in educational facilities. The work of InAirQ, 2019, emphasized the need of integrating financial sources into the management plan by allocating funding from local government budgets to improve air quality, giving participating schools the option of low-cost or no-cost options. It also provides a plan of action in the event that an important component of the plan is absent. In Guyana, international guidelines can be employed because there is an absence of IAQ guidelines for schools.

Although the IAQ at the two participating schools in Guyana is undesirable, Csobod E, et al. [11], InAirQ [12] highlighted Guyana's potential in the field of IAQ management, since developing a policy and plan will help school officials in establishing a healthy learning environment for all.

Material and Methods

This qualitative research employed a case study design to gain insights into a predefined phenomenon without manipulating variables. In this study, both secondary and primary data were collected and reviewed. Moreover, secondary data which was sourced from journal articles, research reports, guidelines and legislation aimed at determining global IAQ policy elements. Meanwhile, primary data, obtained through semi-structured interviews, sought to provide comprehensive insight into an Indoor Air Quality (IAQ) management plan.

The study population included officials from various institutions, headmistresses, teachers and janitors. The sampling technique utilized was generic purposive sampling. It is a non-probability method allowing the researcher to exercise judgment in participants' selection. This facilitated the recruitment of participants capable of offering detailed insight into IAQ for nursery schools. This was important considering the vulnerability of children to air pollution due to their underdeveloped respiratory and immune systems.

Out of the initially identified fifty (50) potential participants, thirty-one individuals participated in the study. The other nineteen (19) teachers and agency representatives were unavailable or declined to participate. The interviews were conducted between January 30th, 2022 to February 10th, 2022, which comprised of six key questions aimed at gaining a comprehensive understanding of IAQ concerns, potential objectives of an IAQ management plan, implementation strategies, enforcement measures and evaluation frequency. Moreover, these interviews conducted by the researcher maintained consistency in data collection and focused on achieving the study objectives.

The study focused on two schools in Demerara-Mahaica, Region (4), Guyana, namely School A and School B, to identify the elements of an Indoor Air Quality (IAQ) policy and management plan for nursery schools. The selection of these schools was based on the prior IAQ assessment conducted by Harlequin R [1] titled "An Investigation on the Indoor Air Quality in 2 Nursery Schools." Harlequin's selection criteria included two primary factors. The schools' location was considered, with one situated near a roadway with moderate traffic and the other near a low-traffic roadway. Harlequin, defined moderate and low traffic as streets with car volumes >100 cars/h and <100 cars/h, respectively El-Sharkawy MFM [13] additionally, the second criterion was based on the design of the schools' building with both being single-story flat structures equipped with both natural (windows and doors) and mechanical ventilation (fans). Harlequin, noted that both schools offered a two-year early childhood program for children aged three years and nine months to five years and nine months.

School A, operational for 8 years, comprised of ten classrooms with approximately 175 pupils, 19 teachers and 2 cleaners. In contrast, School B, 11 years old, has 6 classrooms and a total enrolment of 137 students, 7 teachers and 2 cleaners. To analyse the collected data systematically, content analysis was employed. This method facilitated the organization of data into topics and sub-themes, enhancing the analysis's validity. Content analysis, as outlined by Langos S [14] was chosen for its ability to reduce and simplify data,

aiding researchers in organizing qualitative data to achieve study objectives. The research was conducted at School A (6°49'03" Latitude N. 58°06'46" Longitude W) and School B (6°47'32" Latitude N. 58°07'32" longitude W) [15-19].

Results and Discussion

Poor IAQ can cause adverse health issues such as skin irritation, headaches, nausea and kidney failure. Therefore, guidelines were developed to protect building occupants' health from the dangers of contaminants found indoors. Notably, Guyana lacks guidelines in the field of IAQ. Therefore, WHO's issued guidelines, 2005 for common pollutants were recommended. However, in 2021, the WHO released the revised global air quality guidelines that applied to both indoor and outdoor air quality. It was recommended that the 2005 guidelines be used as an initial step to ultimately achieve the 2021 guidelines. The 2005 guidelines are recommended because the revised guidelines are more stringent and Guyana does not have sufficient air quality measurements. This requires it being done in a stepwise manner. One pollutant for which a guideline has been developed is particulate matter. The 2005 WHO guidelines stipulate the annual mean concentration of PM_{2.5} should not exceed 10 µg/m³. Exposure to pollutants above the threshold limit can cause severe health implications in children such as cardiovascular and respiratory diseases. This finding was consistent with that of InAirQ, 2019, which indicated guidelines from WHO were used to protect building occupants' health in schools because there were no local guidelines for indoor air contaminants in Poland [20,21].

An IAQ policy establishes a framework for preventing and resolving IAQ issues. This section outlined the elements of the IAQ policy. Notably, in the literature review it was established that there was a research gap on the elements of an indoor air quality policy for nursery schools. As a result, this study rectifies these shortcomings.

Two of the participants in this study suggested that definitions be incorporated in the policy to help individuals gain a better understanding and it also makes the policy more efficient. All participants agreed that objectives should be devised to determine if the policy is achieving its goals. Various objectives were provided to ensure that nursery schools have the best possible air quality, collaborate relevant agencies to promote the policy functions and objectives in order to raise awareness, to provide guidance for the development of guidelines, regulations and other instruments, to establish an information system that will collect, analyze, store and disseminate data on IAQ health and environmental outcomes ensuring compliance with IAQ guidelines [22-24].

Guiding principles and policy outcomes were two other aspects of the policy that emerged from the interview. According to one participant, the policy should be driven by principles found in the Environmental Protection Act or the World Health Organization. The importance of guiding principles is that they can aid in decision-making and day-to-day operations, whereas the outcomes are the final changes that the policy will produce such as improved academic performance and reduced absenteeism. Some participants suggested the policy should name an agency as the regulatory authority in charge of the policy's implementation. However, in order to hasten the policy, the regulatory authority should collaborate with other agencies such as UNESCO and UNICEF.

Overcrowding, traffic activity and pests were all mentioned as issues the policy should address. This supports the findings of Harlequin, who also found that high densities of students, traffic activity and pests contributed to poor IAQ in two nursery schools. The policy should have regulations or penalties for not following them. The severity of the penalty should be proportional to the seriousness and nature of the offence. Only four (4) of the participants could identify instances of punishments that could be included in the policy, such as termination, probation, or a written reprimand. Notably, all participants acknowledged the policy should be evaluated on an annual basis to determine its effectiveness.

The Indoor Air Quality (IAQ) management plan is intended to protect building occupants' health and safety and minimize exposure to contaminants. The elements of the IAQ management plan were outlined in this section.

Table 1. Key aspects of documents that was pertinent to the study.

Institutions	Documents	Data Extracted
Ministry of education	Non-Academic education standards	- Class size requirements - Space allocated per child
Ministry of education	National risk management policy for the education sector in Guyana	- Procedures for dealing with emergencies, such as flooding, disease outbreaks like COVID-19. - Infrastructure and equipment of schools such as location of school sites. - Financial resources and communication mechanisms
United States environmental protection agency	Indoor air quality tools for schools coordinator's guide	- Responsibilities of those involved in IAQ Management. - Definition of terms
World health organisation	The right to healthy indoor air	Guiding principles for the policy
Guyana environmental protection agency	Guyana's environmental protection act	Recommendations to reduce IAQ in schools.
United Nations educational, scientific and cultural organisation	Recommendations proposed by the UNESCO chair on health education and sustainable development & sima	Recommendations to reduce IAQ in schools.
Washington state department of health	School indoor air quality best management practices manual	Recommendations to reduce IAQ in schools.

The majority of participants acknowledged the IAQ management plan should include a background section that discusses the many IAQ issues that affect schools and the impact they have on building occupants, particularly children. This aspect could alert appropriate authorities, staff and parents to the fact that IAQ is a serious health and safety concern that requires immediate attention. Moreover, all participants indicated that clear objectives should be included in the IAQ plan. Several objectives were stated throughout the interview to reduce indoor air contaminants by inspecting and maintaining buildings regularly, to establish an effective communication, investigation and documentation mechanism, to address IAQ issues in a timely and effective manner, to provide a safe and healthy indoor environment for all students and staff, to provide adequate air movement through the installation and repair of ventilation systems, to educate teachers, parents and other stakeholders about IAQ.

Goal displacement can occur when there are no clearly defined objectives. As a result, the objectives provided were used in the plan because they will make it easier to evaluate the plan, the interested parties will be more enthusiastic and spirited if they know what is expected of them, the decision-making process will be guided and personnel accountability will be assured.

Capacity building and IAQ awareness is another key component, according to all teachers and parents interviewed. This is critical because all staff and parents should have a basic understanding of the school's IAQ and how they can assist in the implementation of sound management practices. Capacity building for various target groups can be organized by relevant agencies and accomplished through education, training and seminars. Another component emerging from the study findings was majority of participants believed there is a demand for qualified human resources to monitor IAQ in all schools. Human resources are critical in ensuring that optimal IAQ practices are followed in the siting, design, construction and operation of schools on a regular basis, as well as problems and complaints connected to indoor air are correctly addressed. These findings were consistent with those of Jones et al., stating that human resources, objectives and training are critical components of the plan. One teacher raised an intriguing concern about who to complain to and how to report an IAQ problem impacting occupants or the school. As a result, the teacher suggested incorporating a complaint and response system to describe how complaints and concerns about IAQ are reported and assessed [25-29].

Although Guyana's National Risk Management Policy for the Education Sector does not expressly include IAQ, one participant suggested that it can be used to guide the construction of the IAQ management plan. Some components of the policy, such as the mobilization of financial resources, communication mechanisms and procedures for dealing with emergencies, such as flooding, disease outbreaks like COVID-19, are critical to include in the plan. The aforementioned elements were utilized because the communication system will aid in the alleviation of issues and concerns, as well as generate support for the school's efforts to maintain healthy facilities for staff and students. It is vital to mobilize financial resources in order to avoid and respond to IAQ issues in a timely and efficient manner. Similarly, InAirQ, 2019, discovered in their research that it is necessary to set aside financial resources in local

government budgets for air quality improvement. Furthermore, the participant emphasized factors such as soil quality and flood risk are not taken into account when locating school sites; as a result, the IAQ plan should take this into consideration as well as other procedures for dealing with IAQ issues such as cleaning.

The elements of an IAQ policy and management plan can be adapted from various institutions and incorporated data from the documents listed in Table 1.

Conclusion

Guyana lacks guidelines in the field of IAQ, as such; the World Health Organization's guidelines for common pollutants such as PM_{2.5} were used. The guideline stipulates that the annual mean concentration of PM_{2.5} should not exceed 10µg/m³. Notably, children (3 years 9 months to 5 years 9 months) respiratory and immune systems are still developing; therefore, exposure to pollutants beyond the threshold level could result in severe health problems such as cardiovascular diseases.

This research determined the elements of an IAQ policy for nursery schools. Participants suggested that definition of terms, objectives, guiding principles, applicability, policy outcomes, responsibilities, areas of concern such as pest and traffic activity, enforcement and annual review should be included in the policy. Furthermore, the findings indicated an IAQ management plan can be developed to support the IAQ policy, which included procedures for dealing with various IAQ issues such as pests, class size, traffic activity, site selection, construction (including renovation), operations and emergency. Other aspects of the IAQ management plan highlighted in the interviews were objectives, capacity building, resources, the institution responsible for IAQ, monitoring and evaluation.

Conflict of Interest

The authors have declared that that there are no competing interests.

Authors' Contribution

Craig Harlequin: Conceptualisation, Data curation, Formal analyses, Writing of the manuscript, Review and editing.

Nasrudeen Ally: Writing of the manuscript, Review and editing.

Ameera Fatema Wajidally: Formal analyses, Reviewing and editing.

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