CONCLUSION Chapter 5

5.1 Conclusion

The present study provides a comprehensive, multi-dimensional assessment of IAQ across educational institutions and households in Guwahati and Tezpur. It integrates characterisation of air pollutants, $PM_{2.5}$ exposure modelling (via MPPD), physicochemical characterisation of settled dust, health risk assessments, and an epidemiological evaluation of SBS.

While CO_2 concentrations remained within the acceptable limit of across all sites, $PM_{2.5}$ levels emerged as a significant concern, with all surveyed locations exceeding the WHO's guideline of 15 μg/m³. Notably, $PM_{2.5}$ concentrations in educational institutions and households in Guwahati were 1.56 and 6 times higher, respectively, than those in Tezpur. Furthermore, the MPPD model indicated significantly higher lung deposition of $PM_{2.5}$ in occupants of Guwahati, with the deposited mass and deposition density being 1.54–1.55 times greater in educational settings and 4.25–5.66 times greater in households compared to Tezpur. These values reflect a notably elevated inhalation exposure risk for Guwahati residents, an alarming concern intensified by rapid urban construction and development that continues to deteriorate IAQ. Although Tezpur presently records lower $PM_{2.5}$ concentrations, its ongoing urbanization trends suggest a likely increase in IAP in the near future.

The chemical characterization of settled dust was conducted in educational institutions and households across Guwahati and Tezpur. Among the elements detected, Cd and Pb emerged as the most concerning, as evidenced by pollution risk indices including the Enrichment factor, Contamination factor, and Geo-accumulation Index. The degree of contamination was classified as "very high" at most sites, while the Pollution Load Index exceeded the threshold value of 1 at the majority of locations, suggesting significant pollution load. FTIR and XRD analyses revealed the mineralogical presence of quartz, dolomite, calcite, illite, haematite, and bornite in the dust samples. Health risk assessments indicated elevated non-carcinogenic risks in children, primarily through ingestion, while adults remained within acceptable exposure limits. Additionally, carcinogenic risks were within acceptable thresholds (10^{-6} to 10^{-4}), indicating no substantial lifetime cancer risk due to dust inhalation. The elemental composition of indoor dust was found to be influenced not only by outdoor sources but also by location-specific variables such as household practices, building materials, and adjacent land use patterns, which may further shape the elemental composition of indoor dust.

The risk factors for onset of Sick Building Syndrome included gender, age, smoking, mould/dampness in house, cracks in floors and history of medical conditions. These results emphasize the urgent need for improved housing infrastructure, ventilation, and public health awareness to mitigate the health impacts associated with IAQ in rapidly urbanizing regions like Guwahati.

The identification of Cd and Pb as most concerning element, alongside the quantification of non-carcinogenic and carcinogenic risks, particularly in vulnerable populations like children, highlights the distinctiveness and public health relevance of this research. Additionally, MPPD model estimation of particle deposition in different parts of the human respiratory tract revealed significant differences in inhaled particle load between Guwahati and Tezpur, highlighting the vulnerability of residents in more polluted environments. Moreover, the epidemiological assessment of SBS underscores the need to consider both environmental and lifestyle factors to reduce the prevalence of SBS and improve the health and wellbeing of residents. This integrative approach presents a baseline for future IAQ policies in the Northeast region and similar urbanizing environments.

5.2 Scope for Future Work

There is a need for long-term, seasonal monitoring of size segregated particulate matter (PM_1, $PM_{2.5}$ and PM_{10}) and other indoor air pollutants (volatile organic compounds, radon, bioaerosols) to better understand their temporal dynamics and cumulative health impacts. Incorporating real-time IAQ sensors and advanced exposure modelling can enhance the accuracy of risk assessment.

Further, interdisciplinary studies that combine IAQ measurements with socio-economic and behavioural data could offer more targeted recommendations for improving IAQ through community-specific interventions. Expanding the study to include rural, semi-urban, and urban areas would allow for a broader spatial understanding of indoor pollution across diverse built environments.

There is also scope for exploring the effectiveness of IAQ mitigation technologies, such as low-cost filtration systems, green infrastructure, and sustainable building materials. Additionally, policy development should focus on integrating IAQ standards into building codes, school safety guidelines, and urban planning regulations. Public health campaigns and education programs on IAQ, especially aimed at vulnerable groups such as children and the elderly, can play a pivotal role in reducing health risks and promoting healthier indoor environments.