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Integrated Environmental Quality Assessment and Compliance Analysis of Urban High-Rise Construction: A Field Monitoring Study from Pune, India

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Abstract

Rapid urbanization and infrastructure development have intensified environmental concerns associated with construction activities in urban regions. The present study evaluates environmental quality at an active construction site; Raheja Vistas Towers, Kondhwa, Pune, with emphasis on ambient air quality, environmental noise, and drinking water quality. Monitoring was conducted to assess potential environmental impacts and compliance with regulatory standards. Ambient air parameters including particulate matter (PM_{10}, $PM_{2.5}$) and gaseous pollutants (SO_2, NO_2, CO, O_3, and selected heavy metals) were analysed in accordance with National Ambient Air Quality Standards (NAAQS). Noise levels were monitored following CPCB/MPCB guidelines, while drinking water quality was assessed as per BIS IS 10500:2012. Results indicate that all monitored parameters were within permissible limits; however, Total Dissolved Solids (TDS) slightly exceeded the desirable limit while remaining within permissible limits. The findings suggest effective environmental management practices and highlight the importance of continuous monitoring and sustainable construction strategies in rapidly urbanizing regions.

Keywords: Ambient air quality; Construction activities; Drinking water quality; Environmental compliance Noise pollution; Urban sustainability

Introduction

Rapid urbanization has become one of the defining features of contemporary development, particularly in emerging economies such as India (United Nations, 2019). The steady increase in population within urban centres has significantly intensified the demand for housing, infrastructure, and commercial spaces, leading to a marked rise in construction activities. While such development is essential for socio-economic progress and urban transformation, it also brings considerable environmental challenges. Construction activities place pressure on air quality, generate high levels of noise, and may affect water resources, thereby influencing both environmental sustainability and human health (Guttikunda and Goel, 2013). Various stages of construction, including excavation, demolition, transportation of materials, and the operation of diesel-powered machinery, contribute to the emission of particulate matter and gaseous pollutants. Among these, fine particulate matter such as PM_{10} and $PM_{2.5}$ is of particular concern due to its ability to penetrate deep into the respiratory system and cause adverse health effects (World Health Organization, 2021). In addition, pollutants such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and carbon monoxide (CO) contribute to atmospheric degradation and may further aggravate urban air quality, especially under unfavourable meteorological conditions. Noise pollution represents another significant environmental issue associated with construction activities. The use of heavy machinery, drilling operations, and vehicular movement generates elevated noise levels that can disturb nearby communities. Prolonged exposure to such noise may result in hearing impairment, sleep disturbances, increased stress levels, and reduced overall well-being (Basner et al., 2014). In densely populated urban areas, where construction sites are often located close to residential zones, effective monitoring and management of noise levels are essential to maintain acceptable living conditions. Water quality is equally critical in the context of environmental assessment. Construction activities may

influence water resources through improper waste disposal, accidental spillage of chemicals, and contamination of drinking water supplies. Since access to safe drinking water is fundamental to human health, any deterioration in water quality can lead to serious public health consequences. Therefore, systematic monitoring of physicochemical and microbiological parameters is necessary to ensure compliance with established standards. Environmental Impact Assessment (EIA) provides a structured framework for identifying, predicting, and evaluating the environmental consequences of development projects (Glasson et al., 2013).

It enables decision-makers to implement appropriate mitigation measures that minimize adverse impacts while promoting sustainable development. In the construction sector, EIA plays a crucial role in ensuring that environmental standards are maintained throughout the lifecycle of a project. Monitoring key environmental parameters such as air quality, noise levels, and water quality supports the evaluation of compliance with regulatory guidelines and facilitates effective environmental management. The present study focuses on assessing environmental quality at an active construction site, Raheja Vistas Towers, located in Kondhwa, Pune, Maharashtra. Pune is one of India's rapidly growing metropolitan cities and has experienced a substantial increase in construction activities, raising concerns regarding its cumulative environmental impacts. The selected site represents a typical high-rise residential construction project situated near densely populated areas, making it an appropriate case study for evaluating construction-related environmental effects. The primary objective of this study is to evaluate environmental quality at the construction site through systematic monitoring of ambient air pollutants, environmental noise levels, and drinking water quality. The study further assesses compliance with the National Ambient Air Quality Standards, as well as guidelines prescribed by the Central and Maharashtra Pollution Control Boards and the Bureau of Indian Standards.

By analysing these parameters, the research aims to determine whether ongoing construction activities contribute to measurable environmental stress and to highlight the importance of adopting sustainable construction practices. The findings of this study are expected to contribute to the growing body of knowledge on construction-related environmental impacts and to provide practical insights for policymakers, environmental managers, and construction professionals. A clear understanding of the relationship between construction activities and environmental quality is essential for promoting environmentally responsible urban development and ensuring the well-being of urban populations.

Study Area Description

The present study was conducted at the Raheja Vistas Towers construction site located in Kondhwa, Pune, Maharashtra, India. Kondhwa is a rapidly urbanizing area characterized by mixed residential development and expanding infrastructure activities. The region has experienced significant urban growth in recent years, making it a suitable location for assessing construction-related environmental impacts.

The project involves the development of high-rise residential buildings, with ongoing activities including excavation, material handling, structural construction, and operation of heavy machinery. These activities have the potential to influence the surrounding environment, particularly in terms of air quality and noise levels. The surrounding area is predominantly residential, increasing its sensitivity to environmental disturbances.

Key details of the project are summarized below:

- **Total number of towers:** 11
- **Number of floors:** Most towers consist of 18 floors
- **Total residential units:** Approximately 569

Phases of construction:

- **Phase 1 and Phase 2:** Completed and occupied, including towers T12 and T13
- **Phase 4:** Currently under construction, with expected possession by December 2026, including Tower T11 (Raheja Stellar)
- **Raheja Reserve segment:** Includes towers T7, T8, T9, and T10

The present monitoring study primarily focuses on Tower T11, where active construction activities are ongoing. The site is located at Raheja Vistas Premiere, near Dorabjee Mall, off NIBM Road, Mohammed Wadi, Pune, Maharashtra, India, with a postal code of 411060. The geographical coordinates of the study area are 18.470457° North latitude and 73.908429° East longitude.

The selection of this site is based on its representation as a typical high-rise residential construction project situated in close proximity to inhabited residential areas. This makes it suitable for evaluating the impact of construction activities on ambient air quality, environmental noise levels, and drinking water quality, as well as for assessing compliance with applicable environmental standards.

Fig. 1. Layout plan of Raheja Vistas Towers, Kondhwa, Pune, showing towers, roads, & green areas.

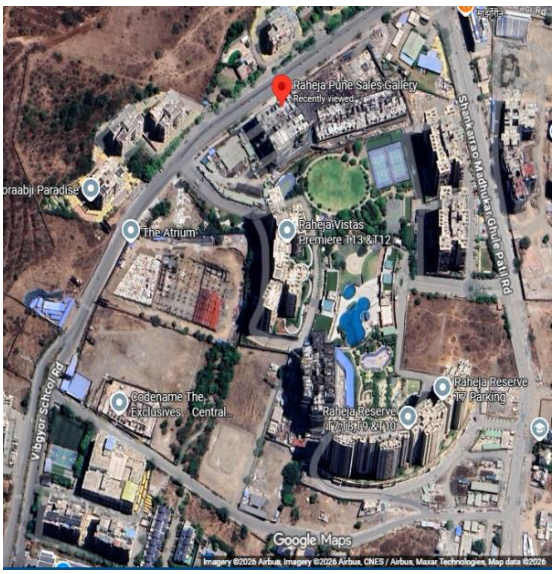

Fig. 2. Satellite view of the study area at Raheja Vistas Towers, Pune (Source: Google Maps, 2026).

Fig. 3. Three-dimensional view of the Raheja Vistas Towers residential complex.

Materials and Methods

The present study was conducted to assess the environmental impacts associated with construction activities at the Raheja Vistas Towers project site in Kondhwa, Pune. Environmental monitoring focused on key parameters, including ambient air quality, noise levels, and drinking water quality. Ambient air quality monitoring was carried out for particulate matter (PM_{10} and $PM_{2.5}$) and gaseous pollutants such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and selected heavy metals. Monitoring and analysis were performed in accordance with standard methods prescribed under the National Ambient Air Quality Standards. Ambient noise levels were measured at selected locations within the construction site during both daytime and nighttime. The monitoring was conducted in accordance with guidelines specified by the Central Pollution Control Board and the Maharashtra Pollution Control Board.

Drinking water samples were collected from the site and analysed for physicochemical and microbiological parameters. The analysis was carried out as per the Bureau of Indian Standards specification IS 10500:2012 for drinking water quality. All monitoring and analytical procedures were conducted using standardized protocols to ensure accuracy, reliability, and compliance with applicable environmental regulations.

Conducting Authority

Environmental monitoring and laboratory analysis were carried out by Greensolution Enviro and Agro Laboratories Pvt. Ltd., a NABL-approved laboratory located at T-71–102, Idea Tower Road, Corner Indrayani Corner, Above HDFC Bank, MIDC Bhosari, Pune, Maharashtra, India, 411026.

Study Design

The study involved field-based monitoring of environmental parameters at the construction site, with a focus on ambient air quality, environmental noise levels, and drinking water quality.

Monitoring Protocol

The monitoring procedures were carried out under the following conditions:

- Air sampling height maintained between 1.5 and 3 m above ground level
- Monitoring conducted over a short-term assessment period
- Instruments calibrated prior to use
- Quality assurance and quality control procedures followed throughout the study

Equipment and Instruments

The following instruments were used for environmental monitoring and analysis:

1. Class 2 sound level meter for measurement of ambient noise levels
2. Particulate matter samplers and gas analyser for ambient air quality monitoring
3. Portable air quality monitoring instruments for on-site measurements
4. Respirable dust samplers and ambient fine dust samplers (PEM-ADS 2.5/10 µm) for particulate matter analysis
5. pH meter, TDS meter, and turbidity meter for physicochemical analysis of water samples
6. Microbiological test kits (H_2S vial/coliform kit) and chlorine tester for microbiological assessment
7. Biochemical Oxygen Demand (BOD) bottles for sample collection and preservation

Results

Ambient Air Quality

The results of ambient air quality monitoring conducted at the study site are presented in Table 1.

Table 1: Ambient Air Quality Monitoring Results

Sr. No.	Parameter	Result	Unit	NAAQ Standard
1	Sulphur Dioxide (SO_2)	24.8	µg/m³	≤ 80
2	Oxides of Nitrogen (NO_2)	28.6	µg/m³	≤ 80
3	Particulate Matter (PM_{10})	67.2	µg/m³	≤ 100
4	Particulate Matter ($PM_{2.5}$)	28.4	µg/m³	≤ 60
5	Carbon Monoxide (CO)	0.58	mg/m³	≤ 4
6	Ozone (O_3)	<20.0	µg/m³	≤ 180

Interpretation

The concentrations of particulate matter (PM_{10} and $PM_{2.5}$) were observed to be within approximately 47 to 67 percent of the permissible limits, indicating controlled dust levels at the construction site. Gaseous pollutants, including SO_2, NO_2, CO, and O_3, were significantly below the prescribed standards. Heavy metals and organic pollutants were below detectable limits, indicating minimal air quality impact during the monitoring period.

Ambient Noise Levels

Ambient noise levels were monitored at selected locations during daytime and nighttime. The results are presented in Figure 4.

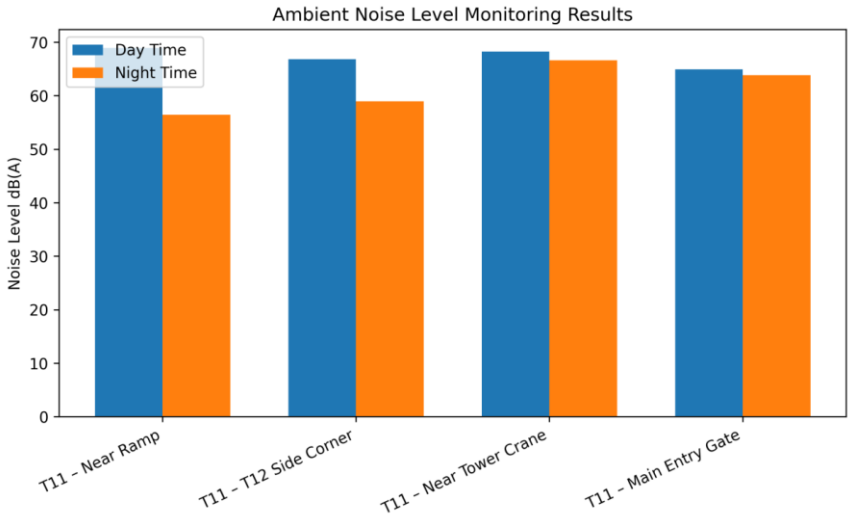

Fig. 4. Ambient noise levels at selected monitoring locations during daytime and nighttime

Interpretation

The recorded noise levels at all monitoring locations were within the permissible limits prescribed by regulatory authorities. Higher noise levels were observed during daytime due to active construction operations, while relatively lower levels were recorded during nighttime. The variation reflects typical construction activity patterns without exceeding regulatory thresholds.

Table 2: Drinking Water Quality Analysis Results (IS 10500:2012)

Sr. No.	Test Parameter	Result	Unit	Desirable Limits (IS 10500:2012)
1	Colour	< 1.0	Hazen	Max 5
2	Odour	Agreeable	—	Agreeable
3	Turbidity	< 0.30	NTU	Max 1
4	pH	6.9	—	6.5–8.5
5	Total Hardness (as $CaCO_3$)	158	mg/L	Max 200
6	Total Dissolved Solids (TDS)	560	mg/L	Max 500
7	Chlorides (as Cl^-)	8.3	mg/L	Max 250
8	Sulphates (SO_4^{2-})	31	mg/L	Max 200
9	Total Alkalinity (as $CaCO_3$)	189	mg/L	Max 200
10	Total Coliforms (MPN)	Absent	—	Absent / 100 ml
11	*E. coli*	Absent	—	Absent / 100 ml

Interpretation

The analysed water quality parameters were within acceptable limits as per BIS standards. Total Dissolved Solids slightly exceeded the desirable limit but remained within permissible limits, indicating acceptable water quality. The absence of total coliforms and *E. coli* confirms that the water is microbiologically safe for drinking purposes.

Results

The environmental quality assessment conducted at the Raheja Vistas Towers construction site indicates that all monitored parameters remained within the prescribed regulatory limits during the study period. The analysis of ambient air quality demonstrates that the concentrations of particulate matter (PM_{10} and $PM_{2.5}$), along with gaseous pollutants such as sulphur dioxide, nitrogen dioxide, carbon monoxide, and ozone, were in compliance with the National Ambient Air Quality Standards. Furthermore, the levels of heavy metals and organic pollutants were below detectable limits, suggesting minimal impact of construction activities on ambient air quality.

Ambient noise monitoring carried out at selected locations during both daytime and nighttime revealed that noise levels were within the permissible limits specified by the Central Pollution Control Board. Although relatively higher noise levels were recorded in proximity to active construction zones, no exceedance of regulatory standards was observed. The analysis of drinking water quality indicates that both physicochemical and microbiological parameters were within the limits prescribed under BIS IS 10500:2012. The absence of total coliforms and *Escherichia coli* confirms that the water was free from pathogenic contamination and suitable for drinking purposes. Overall, the findings suggest that the construction activities at the study site were managed effectively, resulting in minimal environmental impact during the monitoring period. These observations reflect the implementation of appropriate environmental management practices at the site.

Discussion

The findings of the present study indicate that all monitored environmental parameters at the Raheja Vistas Towers construction site remained within the prescribed regulatory limits during the monitoring period. This reflects the effectiveness of the environmental management practices implemented at the site. The observed moderate levels of particulate matter suggest the application of control measures such as water sprinkling, regulated material handling, and dust suppression techniques. When compared with studies conducted in highly polluted urban regions such as Delhi, where construction activities have been reported to significantly elevate particulate matter concentrations (Guttikunda and Goel, 2013), the present site demonstrates relatively lower pollution levels. This comparison highlights the importance of site-specific management practices in mitigating construction-related environmental impacts.

Air Quality Implications

Although the measured concentrations of particulate matter and gaseous pollutants were within permissible limits, it is important to recognize the potential risks associated with prolonged exposure. Fine particulate matter can penetrate deep into the respiratory system and may contribute to respiratory and cardiovascular conditions over time. Construction workers, due to their continuous exposure, may be particularly vulnerable. In addition, sensitive population groups, including children and elderly individuals residing in nearby areas, may experience adverse health effects even at relatively low pollutant concentrations.

Noise Pollution Implications

The recorded noise levels were within regulatory limits; however, continuous exposure to construction-related noise may still have implications for human health and well-being. Prolonged exposure can lead to stress, sleep disturbances, and reduced productivity. In densely populated residential areas, such impacts may affect overall quality of life and may require effective mitigation measures, including controlled working hours and the use of noise barriers.

Water Quality Implications

The drinking water quality at the site complied with BIS standards, indicating that current practices effectively prevent contamination. Nevertheless, any lapse in waste handling or accidental spillage of construction materials could potentially degrade water quality. Continuous monitoring is therefore essential to ensure sustained compliance and to prevent risks associated with microbial or chemical contamination.

Limitations and Environmental Considerations

Environmental conditions at construction sites are influenced by meteorological factors such as wind speed, temperature, and humidity, which affect pollutant dispersion and concentration levels. These factors were not included in the present study and represent a limitation. Incorporating meteorological data in future studies would provide a more comprehensive understanding of environmental dynamics.

Overall Environmental Significance

Although the present study demonstrates compliance with environmental standards, construction activities are inherently dynamic and may vary over time. Without continuous monitoring and proactive mitigation measures, there remains a possibility of fluctuations in pollutant levels. The adoption of sustainable construction practices, including effective dust suppression, regular maintenance of equipment, noise control measures, and proper waste and water management, is essential to minimize environmental impacts. Continuous environmental surveillance, supported by regulatory compliance and stakeholder awareness, is critical to ensuring that construction activities contribute to urban development without compromising environmental quality and public health.

Conclusion

The present study provides a systematic evaluation of environmental quality at an active residential construction site in Kondhwa, Pune, with specific emphasis on ambient air quality, environmental noise, and drinking water quality. The monitoring results indicate that all measured parameters were within the permissible limits prescribed under the National Ambient Air Quality Standards, CPCB and MPCB noise regulations, and BIS drinking water standards during the study period. These findings suggest that construction activities at the Raheja Vistas Towers site were effectively managed and did not result in significant short-term environmental degradation. The observed compliance reflects the implementation of appropriate environmental management practices, including dust suppression, regulated handling of construction materials, controlled equipment operation, and safe water management. Although the results indicate satisfactory environmental performance, construction activities are inherently dynamic and subject to temporal variations. The slight exceedance of Total Dissolved Solids beyond the desirable limit, while remaining within permissible limits, highlights the need for continued monitoring. Regular and systematic environmental surveillance is therefore essential to identify potential fluctuations in pollutant levels and to facilitate timely corrective measures. The study contributes to the understanding of environmental quality management in urban construction settings and provides practical evidence supporting standards-based monitoring approaches. It further emphasizes the importance of integrating environmental safeguards into construction planning and execution to ensure sustainable urban development while protecting environmental quality and public health.

Limitations of the Study

The study has certain limitations that should be considered while interpreting the results:

- Monitoring was conducted over a short duration
- Seasonal variations in environmental parameters were not assessed
- Meteorological factors such as wind speed, temperature, and humidity were not included
- Baseline environmental conditions prior to construction were not available for comparison

Policy Implications

Based on the findings of the study, the following policy implications are suggested:

- Continuous environmental monitoring at construction sites should be made mandatory
- Adoption of sustainable construction practices should be encouraged and enforced
- Regulatory mechanisms should be strengthened to ensure compliance with environmental standards
- Greater coordination between developers, regulatory authorities, and monitoring agencies is essential

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RNM and SB conceived the concept, wrote and approved the manuscript.

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