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From Solid Rock to Airborne Risk: Evaluating Air Pollution in the Road Metal and Building Stone Quarry Industry

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ABSTRACT

This study examines the environmental and health impacts of the quarrying industry in India, with a focus on particulate pollution. Emphasizing the growing demand for construction materials as India's infrastructure expands, the paper explores the implications of increased quarrying activities. Using a robust sampling methodology, the study measured pollution levels, particularly PM10 and PM2.5, in Anakapalle, a significant suburb in the Greater Visakhapatnam Municipal Corporation. Results indicated critical pollution levels, exceeding national standards consistently throughout the study period. A household survey complemented these findings, shedding light on the community's perception of quarry activities. The study underscores the urgent need for effective pollution control measures and sustainable quarrying practices to mitigate adverse health outcomes and environmental degradation. It calls for a balance between development needs and environmental conservation, with recommendations for policy interventions to regulate the industry more effectively.

Key words: *Air quality, Dust management, Environmental health, Particulate matter, Quarrying impacts, Sustainable Practices*

Introduction

The quarrying industry plays a pivotal role in India's infrastructure development, providing essential materials for construction and road building. With India's population projected to reach 1.5 billion by 2030, the demand for road metal and building stone (RMBS) is increasing. Road metal, also known as aggregate, is a key component in road construction, offering strength, stability, and durability to withstand heavy traffic loads and adverse weather conditions(Jonardan Koner, 2022). High-quality road metal is obtained from quarried rocks such as basalt, granite, limestone, and sandstone, ensuring the longevity and safety of India's transportation infrastructure. The construction of buildings, roads, and bridges in our contemporary society heavily relies on crushed stones. To meet the growing demand for road metal, a large number of quarry leases are issued in India. However, the expansion of this industry has raised significant environmental and social concerns. The proliferation of quarry leases and small-scale stone crusher industries has led to regulatory challenges, particularly regarding air pollution control and environmental protection (Newman, 2012).

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In addition, in the construction sector, India is experiencing a boom. As cities expand and modernize, the demand for new residential, commercial, and industrial buildings is on the rise. Building stones, including granite, marble, sandstone, and slate, are widely used in the construction industry for their aesthetic appeal, durability, and versatility. These natural stones are sourced from quarries and processed into various forms such as blocks, slabs, and tiles to meet the specific requirements of architectural projects. The availability of a steady supply of high-quality building stone is vital to sustain the construction sector's growth and meet the diverse design needs of modern structures (Michal Choudhary, 2021).

However, the rapid pace of quarrying also raises environmental concerns. The extraction of rocks and minerals from mountains can result in the degradation and fragmentation of natural habitats, leading to the loss of biodiversity (Orkan Ozcan, 2012). Quarrying activities can disrupt ecosystems, affect wildlife populations, and alter the natural landscape. It is crucial to implement responsible quarrying practices, including site restoration and rehabilitation measures, to minimize the environmental impact and ensure sustainable resource extraction (Salgueiro, 2020).

Additionally, quarrying operations can generate significant dust and noise pollution, impacting nearby communities and ecosystems. Dust emissions from crushing, screening, and transportation of quarried materials can pose respiratory health risks to workers and surrounding populations (Oyedele, 2020).

Study Area

Location and Historical Context

Anakapalle, a suburb now incorporated into the Greater Visakhapatnam Municipal Corporation of Andhra Pradesh, India, holds a place of prominence in the nation's agricultural landscape.

Agricultural Profile

Within the Anakapalle Mandal lies Marturu, the focal point of this study, situated approximately 4 kilometers from Anakapalle town. Marturu is characterized by its agrarian economy, with rice cultivation being the principal agricultural activity. The village is notable for its extensive irrigated fields, encompassing an area of hundreds of hectares, indicative of well-established agricultural practices (Consultants, 2020).

Healthcare and Industrial Activity

Healthcare services in Marturu revolve around a primary healthcare center, which serves as the main medical establishment for the local populace. In addition to its agricultural background, the region has significant industrial activity, marked by extensive quarrying operations for road metal and building stone. Presently, Marturu hosts 60 active quarries. These operations, which can trace their inception to 1982, demonstrate a substantial extraction capability, estimated at thousands of tonnes per quarry per day. To mitigate social disruption, blasting activities are confined to a one-hour window between 1 PM and 2 PM.

Quarrying Leases and Environmental Considerations

The quarry leases cover an expansive area of hundreds of hectares in Marturu, with planned mining activities projected through the period of 2024 to 2031. This protracted engagement with the quarrying industry necessitates a comprehensive evaluation of the environmental and socio-economic impacts. The study aims to scrutinize the interplay between economic progression and environmental stewardship, with an emphasis on sustainable practices.

Materials and Methods

Sampling Methodology

To evaluate the ambient air quality in Marturu, an air high-volume sampler was employed to monitor and analyse the concentration of airborne particulates. This assessment focused on the measurement of particulate matter (PM10 and PM2.5) across a five-year period from 2018 to 2022. The high-volume sampler was strategically positioned in several key locations within the study area to ensure representative sampling of the neighbourhood's air quality.

Parameters and Standards

The study's primary air pollutants parameters were Particulate Matter (PM) with aerodynamic diameters less than 10 micrometers (PM10) and less than 2.5 micrometers (PM2.5). The data collected was

then compared against the National Ambient Air Quality Standards (NAAQS) of India to calculate the Exceedance Factor (EF). This factor is a measure of the extent to which pollution levels surpass the national standards, thus providing an index of pollution severity over the study period.

Sociodemographic and Health Impact Survey

Questionnaire Design

A comprehensive questionnaire survey was administered to a sample of 200 households within the study area. The survey was designed to gather data on a range of variables, including: Demographic characteristics of the respondents, Perceived health and well-being impacts attributable to air quality, observed impacts on agricultural crops and livestock, Levels of noise pollution and its perceived effects, Community perceptions regarding environmental quality, Awareness and attitudes towards environmental issues and policies

Survey Implementation

The survey was conducted by trained interviewers who visited the selected dwelling units. The questionnaire was structured to facilitate both quantitative and qualitative responses, allowing for a detailed analysis of the local population's perceptions and experiences related to environmental conditions.

Data Analysis

The collected data underwent statistical analysis to identify correlations and trends between air quality parameters and the survey responses. This analysis aimed to quantify the relationship between environmental pollutants and their impacts on human health, agriculture, and local perceptions.

Ethical Considerations

All survey participants were informed about the purpose of the study and provided consent prior to participation. Confidentiality of responses was strictly maintained, with personal identifiers removed to ensure anonymity in the subsequent analysis.

Results

As seen figure 1, Maturu is close to the Road metal and building stone mine in the study area almost 1 km. Tens of quarry's were leased for the quarry operations and also there are lot of crushers units also in the study area and within 1km range of marturu neighbourhood. As seen figure 2, a lot of dust emissions being generated during the blasting of quarry in the study which creates lot of air pollution. Figure 3 shows dusty haul roads due to the dry deposition of dust on roads due to air pollution in the study area.

The air pollution monitored during the period 2018-2022 was clearly indicated in the figure 4. The air pollution during all the monitored years have surpassed the annual average permissible limits of National ambient air quality standards for PM 10 and PM 2.5. PM10 crossed the NAAQS standards 3 to 3.5 times and almost 10 times when compared to WHO UNEP standards. The maximum Annual average concentration of PM10 in Maturu recorded highest with 220 $\mu g/m^3$. PM2.5 crossed the NAAQS standards 2.3 to 2.65 times and almost 10 times

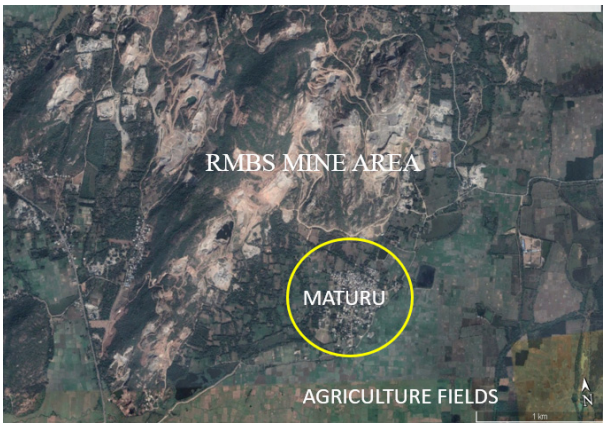

Fig. 1. Satellite image shows the study area maturu& RMBS Mine

Fig. 2. Stone dust generated during the blasting of RMBS Mine causing air pollution

Fig. 3. Dusty Haul roads

when compared to WHO UNEP standards. Annual average concentration of PM2.5 in Maturu recorded highest with 110 µg/m^3.

As per the Air Quality Assessment based on an Exceedance Factor with respective to NAAQS, the air quality has been categorised into four broad categories based on an Exceedance Factor (the ratio of the annual mean concentration of a pollutant with that of a respective standard). The four air quality categories are: Critical pollution (C): when EF is > 1.5; High pollution (H): when the EF is between 1.0 - <1.5; Moderate pollution (M): when the EF between 0.5 - <1.0; and Low pollution (L): when the EF is < 0.5. When exceedance factor was calculated for PM10 and PM2.5 for all the years the exceedance factor was critical for both PM10 and PM2.5 see Fig. 6 and 7.

Air Pollution Monitoring

The study's air quality monitoring, conducted between 2018 and 2022, revealed a persistent exceedance of the National Ambient Air Quality Standards (NAAQS) in the Marturu region for particulate matter. Figures integrated into the study illustrate the proximity of the study area to quarrying activities and the resultant air pollution.

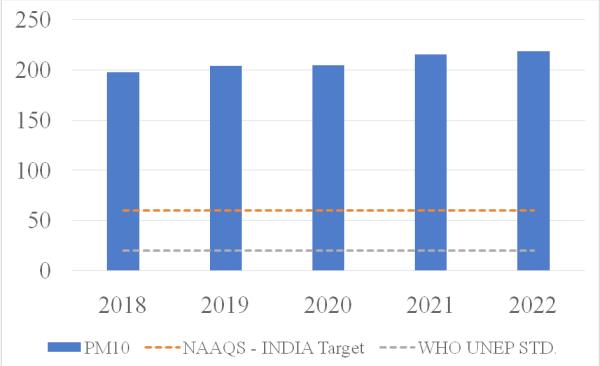

Fig. 4. Annual average concentration of PM10 in study area

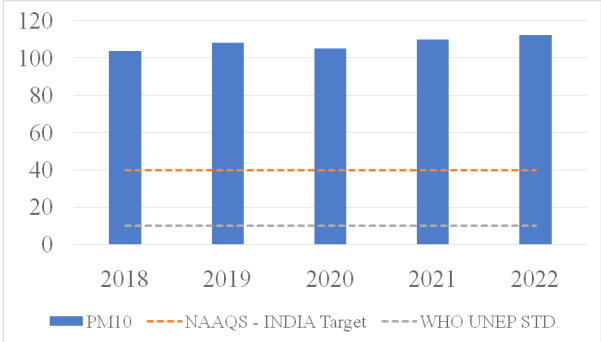

Fig. 5. Annual average concentration of PM2.5 in study area

Human Health Implications

The elevated levels of PM10 and PM2.5 in Marturu pose significant health risks to the local population. Respiratory problems, cardiovascular issues, and decreased lung function are of particular concern,

Year	Pollutant – Particulate Matter (PM10)		
	Pollutant Annual average (µg/m^3)	Exceedance Factor	Air Quality
2018	190	3.166	CRITICAL
2019	205	3.416	CRITICAL
2020	208	3.466	CRITICAL
2021	215	3.58	CRITICAL
2022	220	3.66	CRITICAL

Fig. 6. Air quality assessment (PM10) based on exceedance factor

Year	Pollutant – Particulate Matter (PM2.5)		
	Pollutant Annual average (µg/m^3)	Exceedance Factor	Air Quality
2018	105	2.625	CRITICAL
2019	109	2.725	CRITICAL
2020	105	2.625	CRITICAL
2021	110	2.750	CRITICAL
2022	**113**	**2.825**	**CRITICAL**

Fig. 7. Air quality assessment (PM2.5) based on exceedance factor

with the highest risk groups being the elderly, children, and individuals with pre-existing health conditions (Timothy N. Njagi, 2023). The chronic exposure to particulate pollution also raises the risk of developing allergies, eye irritations, skin problems, and potentially, cognitive health impacts. Furthermore, a weakening of the immune system linked to prolonged PM exposure could increase susceptibility to infections, contributing to an overall decrease in the quality of life and life expectancy in the affected communities (Melania Maria Serafini, 2022).

Environmental Impact

The environment in and around the study area suffering due to the high levels of particulate matter. Visibility reduction due to haze and smog is the most immediate effect, with potential long-term consequences including acidification of water bodies and soil, eutrophication, and ecosystem imbalances (Manisalidis, 2020). The deposition of PM on vegetation can obstruct photosynthesis and damage plant tissues, while water contamination from particulate-bound pollutants poses a risk to both terrestrial and aquatic ecosystems (Sharma, 2022).

Agricultural Concerns

The agricultural sector, a mainstay of the study area economy, is experiencing adverse effects from the particulate pollution. Critical issues include the reduction of photosynthesis due to the deposition of PM on leaves, stomatal clogging affecting plant respiration, and overall crop yield reduction. Visible damage to leaf structures and a decrease in pollination efficiency due to impaired pollinator health further exacerbate the situation. These agricultural impacts have broader economic repercussions, affecting the livelihoods of farmers and the food security of the region (Rai, 2016).

Conclusion and Recommendations

The study's findings highlight a significant environmental and public health concern associated with the quarrying industry in Anakapalle, indicating critical levels of PM10 and PM2.5 that exceed national standards. These results, reinforced by household perceptions, suggest that current quarrying practices poses a threat to the health of local communities and the environment. To effectively address the air pollution emanating from quarry operations, a multi-faceted approach is necessary. Initially, the use of blasting mats should be mandated to diminish the dispersion of dust during explosions. Simultaneously, the strategic placement of water sprinkler systems is crucial for dust suppression within and surrounding quarry zones. Operations should be conscientiously scheduled, with a preference for non-windy conditions to minimize dust prolifera-

Results of Household Survey on Quarry Activities

Category	Subcategory	Result
Demographics	Educational Level	Majority of the head of families have an education level of 10th Class or below.
	Occupation	51% of the respondents are daily wage laborers.
Health and Well-being	Negative Changes in Health	94% of respondents have noticed negative changes in their health and well-being since living near the quarry sites, primarily due to increased air pollution.
	Types of Health Issues	Respiratory Issues: 36%, Eye Irritation: 63%, Skin Problems: 1%
Environmental Concerns	Air Quality	Perception of Air Quality: 95% of respondents rated the air quality as very poor. Awareness of Actual Levels: 100% of residents are not aware of the actual air pollution levels in the neighbourhood. Presence of Dust: 98.4% experience dust in the air all the time.
	Impact on Agriculture	Crops Cultivated: The majority of the crops are paddy. Drop in Yield: 94% observed a decrease in cultivation yield and crop discoloration due to increased air pollution.
	Noise Pollution	Impact: 94% are also suffering from noise pollution, including irritation, sleep disturbances, stress, and anxiety.
Community and Authority Involvement	Community Awareness	93% felt they are aware of the health issues related to air pollution, but no community-based initiatives exist to address these issues.

tion. The installation of real-time monitoring stations at strategic locations would enable constant surveillance of particulate matter levels, and transparent data sharing can help in keeping the public informed and engaged. Technological advancements should be leveraged to transition towards cleaner and more efficient quarrying practices. Moreover, enclosing crusher units and promoting centralized crushing facilities with stringent pollution control measures can substantially reduce airborne dust. The ecological approach includes planting native trees with high pollution tolerance indices to serve as natural windbreakers, effectively reducing the travel of dust. Additionally, it is imperative to support farmers in adapting to these environmental changes by encouraging the cultivation of dust resilient crops and promoting crop diversification to lessen the reliance on more sensitive varieties. Soil testing should be conducted regularly, accompanied by targeted fertilizer recommendations to ensure agricultural viability. In the event of a decline in crop yields attributable to quarry-related pollution, a compensation mechanism should be established to support affected farmers. Finally, public awareness campaigns on the detrimental effects of air pollution and the importance of preventive measures are essential to foster a community that is informed, involved, and invested in sustainable practices.

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Conflict of Interest: None

References

Consultants, S. E. 2020. *Final Environmental Impact Assessment Report Violation of M/S Sri Raja Projects.*

I.V.Y.Rama Rao, K. S. 2016. Assessing the performance of Jaggery market in Andhra Pradesh state, India. *International Journal of Environment, Agriculture and Biotechnology.* 1(4). doi:10.22161/ijeab/1.4.16

Jonardan Koner, B. B. 2022. Road Infrastructure Development and Economic Growth of North-Eastern States in India: A Revisit. *NICMAR- Journal of Construction Management.* 38(4): 86-91. Retrieved from https://www.researchgate.net/publication/371043442_Road_Infrastructure_ Development_and_Economic_Growth_of_North-Eastern_States_in_India_A_Revisit

Manisalidis, I. 2020. Environmental and Health Impacts of Air Pollution: A Review. *Frontiers in Public Health, 8*(14), 1-13. doi:10.3389/fpubh.2020.00014

Melania Maria Serafini, A. M. 2022. Air Pollution: Possible Interaction between the Immune and Nervous System? *International Journal of Environmental Research and Public Health.* 19(1): 1-26. doi:10.3390/ijerph192316037

Michal Choudhary, A. S. 2021. Identifying Challenges of Construction Industry in India. *Turkish Online Journal of Qualitative Inquiry.* 12(6): 539-552.

Newman, P. 2012. *Reducing the environmental impact of road construction.* Brisbane: Sustainable Built Environment, National Research Centre.

Orkan Ozcan, N. M. 2012. Environmental impact analysis of quarrying activities established on and near a river bed by using remotely sensed data. *Fresenius Environmental Bulletin.* 21(11): 3147-3153.

Oyedele E. O, O. O. 2020. Assessment and control of noise and dust pollution in mines and quarries: A review. *World Journal of Engineering Research and Technology.* 6(1): 27-46.

Rai, P. K. 2016. Impacts of particulate matter pollution on plants: Implications for environmental biomonitoring. *Ecotoxicology and Environmental Safety.* 129(1): 120-136. doi:10.1016/j.ecoenv.2016.03.012

Salgueiro, P. 2020. Enhancing Biodiversity and Ecosystem Services in Quarry Restoration – Challenges, Strategies and Practice. *Restoration Ecology.* 28(3): doi:10.1111/rec.13160

Sharma, P. 2022. Impacts and Responses of Particulate Matter Pollution on Vegetation. In ý. S. Saurabh Sonwani, *Airborne Particulate Matter* (pp. 229-264). Springer Nature Singapore. doi:10.1007/978-981-16-5387-2_10

Timothy, N. and Njagi, F. H. 2023. PM10 Levels and Prevalence of Respiratory Diseases in Communities around the Cement Industries. *Asian Journal of Environment & Ecology.* 20(3): 11-23. doi:10.9734/AJEE/2023/v20i3439.