J Prima Med Sains (2025) 7(1):8-15
doi.org/10.34012/jpms.v7i1.6813

ORIGINAL ARTICLE

Public perception of air quality in Aceh District's border areas

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ABSTRACT

Climate change and industrial activities have contributed to a decline in air quality in the border region between Aceh Barat and Nagan Raya Districts, adversely affecting public health, particularly through increased cases of Acute Respiratory Infections (ARI). This study aims to analyze community perceptions of air quality in this area. A qualitative approach was employed, utilizing in-depth interviews with residents of border villages who were purposively selected based on criteria including a minimum of five years of residency, experience of health impacts, and involvement in community activities. Data collection was supplemented by field observations and secondary documents obtained from relevant agencies. The findings indicate that local communities experience direct effects of air pollution, such as exposure to dust, eye irritation, and respiratory problems, especially during the dry season and periods of increased heavy vehicle activity. However, official government monitoring remains limited and does not include measurements of fine particulate matter (PM2.5 and PM10), resulting in a gap between technical data and community experiences. Residents also noted a lack of public awareness campaigns addressing the health risks associated with air pollution. The study concludes that community-based approaches and data transparency are essential for effective air quality management. A key policy recommendation is the adoption of a hybrid air monitoring system that integrates technical measurements with community-reported experiences, thereby informing more responsive environmental and public health interventions.

Keywords: air quality, public perception, dust pollution, respiratory health

INTRODUCTION

Climate change and industrialization have significantly contributed to declining air quality across various regions in Indonesia, including the border areas between Aceh Barat and Nagan Raya Districts. These areas possess unique geographical and socioeconomic characteristics, as noted by the Meteorology, Climatology, and Geophysical Agency (BMKG). Rising global temperatures alter local weather patterns, which in turn affect the dispersion and concentration of air pollutants.[1] Meanwhile, industrial activities such as coal-fired power plants (PLTU), palm oil processing, cement production, and coal mining emit fine particulate matter (PM2.5 and PM10) and gases such as SO_2 and NOx. These pollutants can persist in the atmosphere for extended periods, traveling far from their original sources and exacerbating air quality degradation over a wide area.[2]

Aceh Barat and Nagan Raya Districts are neighboring administrative regions strategically located along the southwestern corridor connecting to the provincial capital. This corridor serves as a critical logistics route on the Trans-Sumatra Highway, with a high volume of heavy vehicles transporting mining products and industrial commodities.[3] Active industries in the vicinity, including the coal power plant and mining operations, further exacerbate local air pollution through continuous emissions of dust and fine particulates. Data from Air Quality Index and the Ministry of Environment and Forestry (KLHK) in 2023 demonstrate a notable decline in air quality in several parts of Aceh.[4] Specifically, PM2.5 concentrations in industrial and transport-heavy areas periodically exceed the World Health Organization's recommended annual limit of 15 µg/m³, indicating a substantial risk to public health.[5] Aceh Barat and Nagan Raya are classified as moderate to high-risk zones for air pollution during peak industrial and transportation activities.[6]

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Acute Respiratory Infections (ARI) were a leading health concern in Aceh in 2024, according to data from the Provincial Health Office. Community health centers across both districts frequently reported ARI cases, highlighting its prevalence in the region.[7] These diseases consistently appear among the top five most prevalent health issues, posing a serious public health concern. Interestingly, many affected individuals reside far from industrial centers, suggesting that air pollutants disperse widely and impact populations beyond immediate industrial zones. This observation supports the hypothesis that air pollution from industrial and heavy vehicle emissions significantly contributes to the rising incidence of ARI across the region.[8,9]

While academic research often highlights objective measurements like PM2.5, PM10, and SO_2 levels when studying air pollution, it frequently overlooks the crucial subjective experiences and perceptions of local communities regarding these issues.[10,11] Understanding community perceptions is crucial for effective pollution management. The community's awareness of pollution, their health concerns, and their expectations significantly influence individual behaviors toward pollution prevention and their support for environmental policies. This study addresses a specific gap by examining how residents of the Aceh Barat–Nagan Raya border region perceive the air quality they experience daily. By integrating scientific knowledge of environmental health with the perspectives of the local community, this research aims to provide valuable insights. These insights can inform the development of culturally sensitive educational programs and effective air pollution control strategies that genuinely address the community's needs.

METHOD

This study employed a qualitative approach using in-depth interviews to explore community perceptions of air quality in the border area between Aceh Barat and Nagan Raya Districts. The qualitative method was chosen to obtain a contextual and reflective understanding of community experiences in facing air pollution issues.[12,13] The study focused on villages situated along the border of two districts. These villages were chosen for two key reasons: first, they had a high incidence of ARI between 2022 and 2024, as documented by the Padang Rubek and Meureubo community health centers (Puskesmas). Second, their close proximity to industrial areas and the Trans-Sumatra Highway, a major transportation route, made them relevant to the research.

Data on ARI cases were obtained from official reports of the Puskesmas Meureubo and Puskesmas Padang Rubek, which serve as key indicators for assessing the potential impact of air pollution on community health. It was observed that Puskesmas Meureubo consistently reported a higher number of ARI cases compared to Puskesmas Padang Rubek, with this trend remaining relatively stable throughout the 2022–2024 period. This study involved a total of 12 informants. Among them, eight community members were purposively selected based on three key criteria: having resided in the border area for at least five years, having direct experience with respiratory disorders either personally or through family members, and being actively engaged in community activities or environmental health programs. Additionally, the informant group included one village official from each area and one representative from the District Environmental Agency (DLH).

Data collection was conducted through semi-structured interviews, supplemented by field observations, documentation, and secondary data such as ARI reports from health centers, Air Quality Index (AQI) data, and records from the Ministry of Environment and Forestry (KLHK) related to air quality and ARI cases. Data analysis was performed using narrative-descriptive methods. All interviews were transcribed verbatim and analyzed to identify common patterns, perceptual variations, and dominant factors influencing air pollution and its health impacts. To enhance data validity, triangulation of data sources, member checking, and thick descriptions were employed to ensure the rigor and reliability of the findings.[14] Ethical considerations were strictly observed through informed consent procedures, including clear explanations of the study objectives and assurances of participant confidentiality. Participation was voluntary, and informants were free to withdraw at any time.

RESULTS

This study revealed that air quality in the border region between Aceh Barat and Nagan Raya districts has emerged as a significant public concern, especially among residents living near industrial zones and major transportation corridors. Interviews with diverse stakeholders (including officials from the Environmental Agency (DLH), village government representatives, and local residents) uncovered several

key findings related to community perceptions, firsthand experiences, and the effects of air quality on daily life and health outcomes.

Limited air quality monitoring

The Environmental Agency (DLH) acknowledged that air quality monitoring in the region is conducted only two to three times annually using passive sampling instruments. The monitoring primarily targets gaseous pollutants, such as SOx and NOx, but excludes particulate matter (PM2.5 and PM10), which are widely recognized as the most significant contributors to respiratory health risks.

> "*We measure air quality three times a year using passive equipment and send the results to the Ministry of Environment and Forestry. Since last year, we haven't received the results back.*" (AC – DLH Nagan Raya)

In addition, public access to air quality data is extremely limited. The reports are submitted solely to local government officials (i.e., the regent) and are not disseminated to the general public.

> "*The community cannot access it. We only submit it to the regent; it is not for public distribution.*" (DLH Official)

Although there are plans to improve accessibility through the national monitoring application managed by the Ministry of Environment and Forestry, local implementation remains lacking.

Direct community complaints: Dust, irritation, and respiratory issues

Residents of Peunaga Cot Ujong and Suak Puntong villages reported frequent exposure to airborne dust, particularly during the dry season and when heavy vehicular activity is high. Dust accumulation inside houses was common, even with windows closed.

> "*At night, if you use a flashlight, you can see the dust particles flying. Children often sneeze and have itchy eyes, but we never go to the clinic*." (SM – Peunaga Cot Ujong)

> "*I have to sweep the house twice a day because of the dust, especially during the dry season.*" (NR01 – Resident)

While many respondents did not report severe health effects, some acknowledged that the dust caused respiratory discomfort.

> "*At night, I often have shortness of breath. When the dust gets worse, it becomes harder to breathe.*" (AR03 – Resident)

Residents in Peunaga Cot Ujong and Suak Puntong villages consistently reported increased levels of dust, particularly during dry seasons and heavy traffic periods. These conditions were linked to symptoms such as eye irritation, sneezing, coughing, and even shortness of breath at night. Some residents mentioned they had to sweep their homes twice daily due to excessive dust accumulation.

Based on the study by Pertiwi et al.[15], long-term exposure to PM2.5 and PM10 in areas near industrial activity significantly increases respiratory complaints. Similarly, Hikmiyah[16] found that communities living along busy transportation routes reported more frequent respiratory symptoms, particularly among children and the elderly. Barasa et al.[17] also demonstrated that semi-urban populations exposed to fine particulates experienced a higher risk of respiratory disturbances. Limited access to information significantly influences public risk awareness. Notoatmodjo[18] emphasized that a lack of environmental health education is strongly associated with low preventive behaviors at both individual and community levels. This finding is highly relevant to the study area, where environmental education and public access to air pollution data remain limited.

As a preliminary indicator, secondary data from the Health Office shows the number of Acute Respiratory Infection (ARI) cases recorded in the working areas of Meureubo and Padang Rubek Community Health Centers (Puskesmas), which respectively oversee the villages of Peunaga Cot Ujong and Suak Puntong—the two villages observed in this study. It is important to note that these figures represent

the total number of cases across all villages within the respective health center coverage areas, not solely from the study villages.

In the Meureubo Health Center's catchment area, the total number of acute respiratory infection (ARI) cases reached 3,400 in 2020 and increased to 4,006 in 2022. Although there was a decline to 3,373 cases in 2023, the figures still indicate a substantial disease burden. Meanwhile, the Padang Rubek Health Center reported 814 ARI cases in 2020, with numbers remaining relatively stable through 2022 (809 cases), before decreasing to 526 in 2023 and further to 146 in 2024. While these data do not directly reflect the specific conditions in Suak Puntong and Peunaga Cot Ujong, the marked disparity in ARI incidence between the two health center regions may serve as an early indicator of environmental factors—such as air quality—contributing to respiratory illnesses. This is particularly relevant in areas with heavy traffic or proximity to emission sources like coal-fired power plants (PLTU).

This pattern aligns with public perceptions that air quality worsens during the dry season and is consistent with previous studies, which demonstrated that long-term exposure to PM2.5 significantly increases the risk of ARI. Therefore, it is crucial to improve community environmental literacy and provide public access to air quality information to support more effective disease prevention strategies.[19,20]

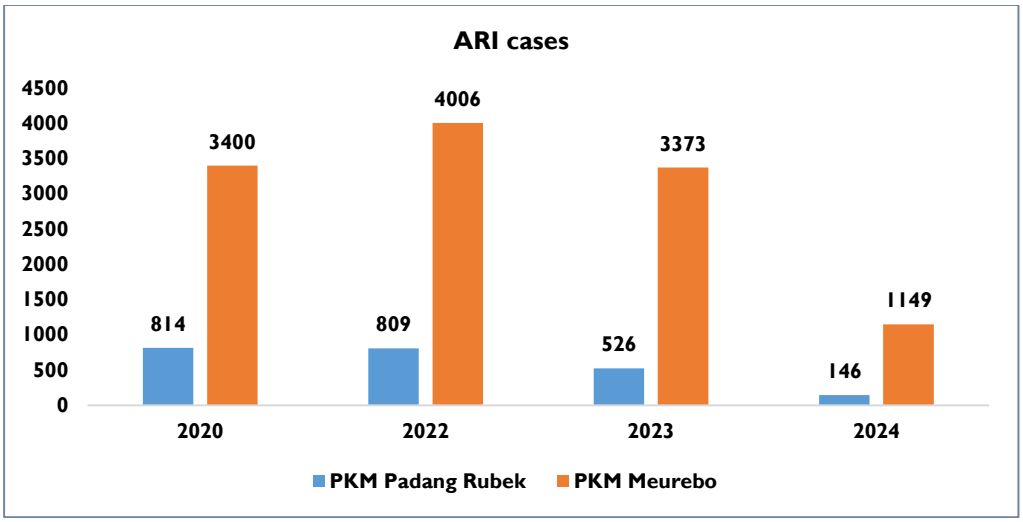

Figure 1. Number of ARI cases at Padang Rubek and Meurebo Community Health Centers

Lack of public education and awareness

Most community members reported never receiving education or information regarding the health risks of dust exposure from government or industrial actors.

> "*I don't know anything about the effects of dust. There should be a notification from the government or the company*." (NR01 – Resident)

Village officials confirmed the absence of risk communication efforts, assuming that residents were already familiar with the risks due to their work in the industrial sector.

> "*There's no special socialization because people are assumed to know. They work on those projects, so they understand the conditions.*" (Village Official)

Community suggestions and expectations

Residents expressed a desire for more proactive measures to reduce dust exposure. Their suggestions included regular road watering (even beyond industrial zones) and the planting of trees or vegetative barriers along transport routes to serve as dust filters.

> "*I hope there will be real action, like watering the roads or planting trees to reduce the dust.*" (NR03 – Resident)

These proposals are supported by findings from Pratama et al.[21] which demonstrate that vegetative buffers can effectively reduce airborne pollutants in industrial and roadside environments.

Stakeholder responses

Local officials and DLH personnel generally perceived the air quality as still "normal" and not requiring urgent action, except during specific weather conditions.

> "*The air condition is still normal, not too severe. Only during the dry season and strong winds does the dust become intense.*" (KA01 – Village Official)

DLH justified the absence of health risk communication by citing the results of their limited monitoring activities.

> "*Since our monitoring shows that the air is still good, we don't do any special socialization.*" (DLH Official)

When asked further, several DLH representatives acknowledged limitations related to funding, equipment, and human resources, as well as the lack of central government instructions.

> "*We are also limited in terms of equipment and personnel. Without instructions from the central government or additional funding, it's difficult for us to take further action.*" (AC – DLH)

Nevertheless, DLH stated that they are planning to conduct Total Suspended Particulate (TSP) monitoring with data updates every two hours in the near future. There is a clear disconnect between official assessments, which claim air quality is within safe limits, and the lived experiences of local communities who report frequent dust exposure and related health complaints. The current monitoring system does not capture fine particulate matter, which likely explains the discrepancy between reported symptoms and monitoring results.

Moreover, the lack of public access to environmental data and absence of health risk communication efforts leave vulnerable populations unprotected. These findings underscore the importance of participatory and community-based monitoring approaches that incorporate local perceptions alongside technical measurements to develop more accurate and inclusive environmental health interventions.

DISCUSSION

The findings of this study reveal a significant gap between the technical results of air quality monitoring and the lived realities experienced by communities in the border region of Aceh Barat and Nagan Raya Districts. Despite official reports indicating that air quality remains within the "good" administrative category, residents continue to suffer direct pollution impacts, particularly from high dust exposure. This study robustly supports the framework of the Social Construction of Environmental Problems, which argues that environmental issues are not solely understood through objective scientific measurements but are also profoundly shaped by social perceptions, cultural values, and community experiences. The core tenet of this theory is that environmental problems become "real" or "significant" when communities collectively define and respond to them, influenced by language, symbols, and social interactions.[22–24] In this context, the community's perception of air quality is primarily shaped by direct sensory experiences (what individuals see, inhale, and physically feel) rather than solely relying on official data, which may be inaccessible or incomplete. For instance, although the Environmental Agency reports that air quality is good, residents such as SM from Peunaga Cot Ujong have reported visible dust that causes irritation and respiratory discomfort.

Furthermore, limited dissemination of pollution information significantly contributes to the community's low risk awareness, a phenomenon that can be effectively explained using the Health Belief Model (HBM). This model describes health behavior based on five key components: perceived susceptibility (likelihood of contracting illness), perceived severity (seriousness of illness), perceived benefits (belief in the effectiveness of action), perceived barriers (obstacles to taking action), and cues to action (triggers for behavior change). Due to insufficient education regarding pollution and its impacts, the community often perceives the risk as low or normal, leading them to treat symptoms like coughing or eye irritation as ordinary ailments. Studies by Agung & Laksono[19] and Putri & Sriwahyuni[7] align with these results,

demonstrating that chronic exposure to PM2.5 increases the risk of respiratory infections, especially among vulnerable groups such as children and the elderly.

A critical issue identified is the technical-experiential data gap, whereby local air quality monitoring has thus far focused exclusively on sulfur oxides (SOx) and nitrogen oxides (NOx). Importantly, fine particulate matter (PM2.5 and PM10) (widely recognized as primary contributors to adverse health outcomes) remains unmonitored. This limitation results in significant underestimation of the actual health risks faced by the community, as fine particles can penetrate deep into the lungs and enter the bloodstream, leading to serious respiratory and cardiovascular diseases. The findings of this study align with previous research indicating that monitoring only SOx and NOx offers an incomplete assessment of air quality and may foster a false sense of security in official reports.[25,26]

Moreover, significant structural response gaps and participation deficits exist. Village leaders often assume that residents "already know" about the impacts of dust, resulting in minimal educational and socialization efforts from authorities. However, residents report low awareness and poor communication regarding pollution risks. To bridge this gap, effective mechanisms could include holding regular community forums or village meetings to facilitate information exchange and feedback among the Environmental Agency, village officials, and residents; creating easily understood and locally relevant educational materials (such as posters, radio broadcasts, or social media content) that detail pollution sources, health impacts, and protective measures; and developing participatory air quality monitoring groups trained to collect and report data, thereby fostering a shared sense of ownership over environmental health. These approaches align with established environmental governance principles emphasizing transparency, inclusiveness, and collaboration.[27] Furthermore, other studies affirm the effectiveness of community involvement in air quality management.

Despite limited technical expertise, residents have proposed practical mitigation strategies that highlight local wisdom as a potential solution. These suggestions include road sprinkling to reduce dust, planting buffer vegetation, and installing taller industrial fences—measures that align with global best practices in nature-based pollution control. Studies by Abidin et al.[28] and Abidin et al.[29] demonstrate that vegetation effectively captures dust particles and improves local air quality. Furthermore, actively engaging the community in implementing these measures can significantly enhance their effectiveness and sustainability.

A key finding also highlights the influence of seasonal weather influences on perceptions. Dust disturbances peak significantly during dry seasons and periods of heavy vehicle traffic, while rainy seasons bring about perceived improvements in air quality. As noted by both residents and officials, "*During dry season with strong winds, dust flies everywhere. During rains, we feel nothing.*" Environmental meteorology explains this phenomenon: dry conditions reduce humidity, allowing dust from unpaved roads and industrial activities to become airborne more easily.[30,31] Strong winds then effectively distribute these particles into residential areas, especially in the absence of vegetative barriers. Conversely, rains facilitate wet deposition, nature's own air cleansing process where precipitation removes atmospheric particulates. Hidayati et al.[32] found that high rainfall correlates with reduced PM10 concentrations. In the context of this region (with heavy Trans-Sumatra Highway traffic and open industrial sites) dust pollution becomes particularly visible and problematic during dry seasons when natural cleansing is absent. Thus, residents' perceptions of "clean" rainy-season air versus "dirty" dry-season air accurately reflect scientifically valid seasonal patterns that should inform both monitoring and mitigation systems.

This discussion underscores that community air quality assessments, far from being merely subjective, actually reflect environmentally grounded observations that can significantly strengthen technical monitoring systems when properly integrated. The findings advocate for hybrid monitoring approaches that value both scientific measurements and community experiential knowledge. This study ultimately reveals a systemic gap between official air quality monitoring systems and the lived realities of communities in Aceh's border regions—a gap that is not isolated but rather mirrors a recurring pattern reported in various studies across Indonesia.

As demonstrated by Siregar[33] in North Sumatra, the social construction of environmental issues is often shaped by direct community experience, particularly when access to valid environmental data is limited. This parallels the situation in Peunaga Cot Ujong, where residents base their understanding of air pollution on daily symptoms rather than official information. Limited access to information significantly affects public risk awareness. Notoatmodjo[18] emphasized that a lack of environmental health education strongly correlates with low levels of preventive behavior at both individual and community levels. These

findings are further supported by studies from Agung & Laksono[19] and Nurhayati et al.[20] conducted in industrial zones, which show that long-term exposure to PM2.5 increases the risk of ARI by up to 2.3 times, especially among vulnerable groups such as children and the elderly. In essence, without adequate information, communities are not only less vigilant but also more susceptible to the adverse health impacts of air pollution.

Technical limitations in air quality monitoring systems also emerged as a significant concern. Syahputri's research[25] reported that 78% of monitoring stations in Jakarta do not measure PM2.5, despite fine particulates accounting for approximately 65% of total air pollution. This finding critically underscores the limitations of the passive monitoring systems still employed by local environmental agencies (DLH) in many regions, including the study area, as the inadequate scope of monitoring parameters prevents a comprehensive assessment of environmental risks. Furthermore, the lack of community participation in environmental policymaking aligns with findings by Ummah[34] in Surabaya, which revealed that 85% of environmental policies were developed without input from affected communities. Yet, community involvement is crucial for fostering sustainable solutions. A study by Abidin et al.[28] in Makassar demonstrated that nature-based solutions, such as vegetation planting, can reduce PM10 concentrations by up to 27% within a 100-meter radius, illustrating that integrating local wisdom and open-space interventions can be both effective and participatory. Seasonal patterns identified in this study also reinforce previous findings. For instance, Hidayati et al.[32] and Mondiana et al.[35] observed that PM10 levels in West Jakarta increased by up to 45% during the dry season. Similar results were reported by Aisyi & Yuwono[31] in Yogyakarta, where strong winds accelerated the spread of industrial dust into residential areas, worsening community exposure.

Based on these comprehensive findings, it can be concluded that addressing air pollution in Indonesia (especially in regions with complex geographic and social characteristics such as Aceh's border areas) requires a more holistic and inclusive approach. A significant policy reorientation is essential, focusing on expanding monitoring parameters to include PM2.5 and PM10, as recommended by the Ministry of Environment and Forestry; developing transparent and easily accessible environmental information systems for the public; implementing participatory approaches in environmental policymaking and enforcement; and effectively utilizing local wisdom and nature-based solutions to mitigate air pollution. The author firmly believes that a purely technocratic approach is insufficient to tackle complex air quality issues, particularly in border regions. Instead, an integrated framework (one that seamlessly combines scientific data, invaluable community experiences, and adaptive, participatory policies) is essential for formulating holistic and truly sustainable solutions.

CONCLUSION

This study highlights significant air quality concerns in the border region between Aceh Barat and Nagan Raya Districts, especially among residents near industrial zones and heavy traffic routes. Although government data classify air quality as "good," local perceptions contradict this, with residents reporting negative impacts (such as dust infiltration, eye irritation, coughing, and shortness of breath) particularly during the dry season, strong winds, and increased heavy vehicle activity. Conversely, the rainy season is perceived as improving air freshness. These perceptions stem from daily experiences and limited access to official information.

Findings show that community perceptions align closely with weather patterns, seasonal changes, and human activity intensity. Due to limited education, outreach, and data transparency, residents rely on their own assessments, which reflect actual environmental conditions and serve as valuable indicators for early warning and policy development. Hence, technical air quality monitoring should be complemented by participatory approaches incorporating community insights. Supported by the Health Belief Model and the Social Construction of Environmental Problems theory, this study argues that community voices are essential in air pollution control in ecologically sensitive border areas. A hybrid monitoring framework combining scientific data with community knowledge will enhance policy relevance, public awareness, and air quality management effectiveness in these vulnerable regions..

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