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# Assessing the Gap Between Regulation and Reality: Community Perspectives and Spatial Siting of Gas Stations in Kumasi, Ghana

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**Research Article**

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## Abstract

In this study, the perceived environmental impacts of gas filling stations and their compliance with buffer zone regulations were evaluated in Kumasi, Ghana's second-largest city. Rapid urbanization has increased energy demand and contributed to the expansion of Liquefied Petroleum Gas (LPG) stations into residential areas. Although LPG is regarded as a cleaner fuel option, its distribution infrastructure may create environmental and safety risks when poorly sited or inadequately regulated. A mixed-method design was employed, combining a household survey (n = 103), spatial analysis, and key informant interviews with station managers, assembly members, and environmental regulators in the Oforikrom sub-metropolis. The findings show substantial community concern regarding gas filling stations. Air pollution, including fuel odours and possible exposure to volatile organic compounds (VOCs), was the most frequently reported issue, cited by 73.8% of respondents. More than two-thirds of residents perceived the overall environmental impact as severe or very severe. Spatial analysis of one station at Anloga Junction revealed non-compliance with the EPA's mandatory 100-meter buffer zone, with the station located only 40 m from a school and 35 m from a market. In addition, awareness of chronic health risks was limited, and 87.4% of respondents reported no involvement in station siting decisions. The findings suggest that current enforcement remains largely reactive and constrained by limited resources. The study recommends stronger spatial planning, stricter enforcement, community-based air quality monitoring, tiered penalties, and locally appropriate public awareness campaigns.

**Keywords:** *LPG filling stations, spatial siting, perceived environmental impacts, regulatory enforcement, buffer zone compliance, Kumasi.*


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## Introduction

The global population is projected to reach 9.7 billion by 2050, increasing pressure on energy resources and accelerating the search for cleaner and more efficient fuel options. In Ghana, as in many developing countries, Liquefied Petroleum Gas (LPG) has been promoted as a cleaner alternative to traditional fuels such as coal, charcoal and wood biomass because of its potential to reduce indoor air pollution and greenhouse gas emissions (Oludaisi et al., 2018; Dongzagla and Adams, 2022). The discovery of offshore gas reserves and the adoption of national energy policies, including the Gas Master Plan, have further encouraged the expansion of LPG use, particularly in rapidly growing urban centres such as Kumasi (Mohammed et al., 2022). As demand for domestic and commercial energy has increased, gas filling stations have become more common within mixed residential and commercial areas (Antwi et al., 2024).

Despite the environmental benefits associated with LPG as a fuel, its storage and distribution infrastructure may create local environmental and safety risks when stations are poorly sited or weakly regulated. Gas filling stations can contribute to air pollution through fuel odours, leaks, spills and emissions of volatile organic compounds (VOCs), including benzene, a known carcinogen (Hilpert et al., 2015; Chaiklieng et al., 2019). In addition, underground storage tanks and accidental spills may contaminate soil and groundwater with petroleum hydrocarbons, while routine station activities, delivery trucks and customer traffic may generate noise and other disturbances for nearby communities (Mucci et al., 2020; U.S. EPA, 2021; Fei-Baffoe et al., 2024). These risks are particularly relevant in dense urban neighbourhoods where gas stations are located close to schools, markets, homes and other sensitive land uses.

Ghana has an established regulatory framework for the petroleum and gas sector. The National Petroleum Authority (NPA), the Energy Commission and the Environmental Protection Agency (EPA) share responsibility for oversight, while the Environmental Assessment Regulations (LI 1652) and the Petroleum Act (Act 919) require Environmental Impact Assessments and set safety standards. The EPA also requires a 100-meter buffer distance between gas stations and sensitive land uses such as schools, hospitals and residential structures (EPA Ghana, 2020). However, previous studies suggest that compliance with siting standards remains uneven in urban Ghana and that enforcement is often constrained by limited institutional capacity and reactive, complaint-based monitoring (Dongzagla et al., 2023). This creates a gap between regulatory provisions and everyday community exposure.

Although existing studies have examined fuel choice, LPG adoption and the spatial distribution of fuel stations in Ghana, less attention has been given to how residents perceive the environmental risks of nearby gas stations and how these perceptions relate to siting compliance and enforcement practice. This study therefore examines community perceptions of environmental risks, awareness of chronic health hazards, involvement in siting decisions and the spatial compliance of a selected gas filling station in Oforikrom, Kumasi. The study is guided by the hypothesis that gas stations located close to sensitive land uses and operating under weak enforcement conditions are associated with higher perceived environmental risk among nearby residents and lower confidence in regulatory protection.

## Materials and Methods

### *Study area and data collection*

The study was conducted in the Kumasi Metropolis, Ghana's second largest city and a major economic centre. Oforikrom, particularly the area around Anloga Junction, was selected because of its high population density, mixed residential-commercial land use and visible concentration of gas filling stations. These characteristics made the area suitable for examining community perceptions and siting-related concerns associated with gas station operations (Figure 1).

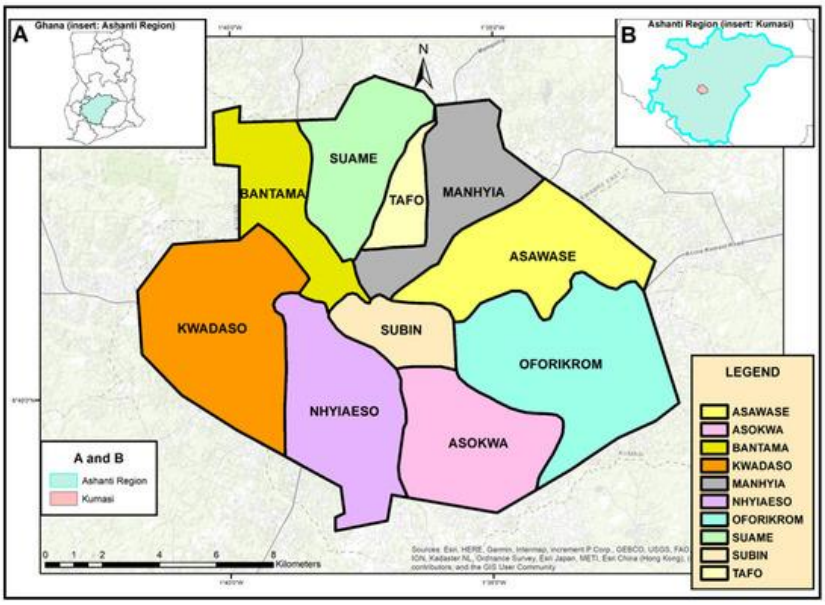


Figure 1. Map of Kumasi Metropolis showing the location of Oforikrom. Adapted from Frimpong and Molkenthin (2021).

A mixed-method design was adopted. A total of 103 participants were involved, comprising 99 household respondents who completed semi-structured questionnaires and four key informants who participated in in-depth interviews. The key informants included one traditional authority, one local assembly member, one gas station manager and one officer from the Environmental Protection Agency (EPA). The household survey sample size was calculated using Slovin's formula, $n = N / (1 + Ne^2)$, where $N$ represents the estimated number of households in Oforikrom and $e$ represents the margin of error. Based on an estimated 30,000 households and a 10% margin of error, the minimum household sample size was calculated as 99 respondents.

### *Spatial analysis*

One gas filling station at Anloga Junction was purposively selected for spatial analysis because it was the largest and most central station in the study area and had previously been the subject of complaints from residents to the local assembly. Distances were measured using a Bosch GLM 50 C laser rangefinder and verified with Google Earth Pro high-resolution satellite imagery. Straight-line distances were calculated from the closest fuel dispensing pump or tank vent pipe to the property boundary of each sensitive land use, namely a basic school, residential building and market centre.

This analysis was treated as an illustrative case study and was not intended to be statistically representative of all gas stations in Kumasi.

### *Data analysis*

Quantitative survey data were cleaned using KoBoCollect, exported to Excel and SPSS, and analysed using descriptive statistics, including frequencies, percentages and tables. Qualitative interview data were analysed thematically to identify common patterns related to environmental concerns, awareness, enforcement and mitigation. Ethical approval and participant consent procedures are reported in the Ethical Approval Statement section.

## Results

### *Respondent profile*

A total of 103 household survey respondents were involved in the study. The sample gender and age distribution is indicated in Table 1. There was a fairly balanced gender distribution, with males representing 53.4% (n = 55) and females representing 46.6% (n = 48). The age group of 36–45 years was the most dominant, with a sample proportion of 41.7% (n = 43), showing that the majority of respondents were mature adults who were probably heads of households and decision makers. Young adults aged 26–35 accounted for 25.2% (n = 26), while those aged 18–25 represented 21.4% (n = 22). Residents aged 46 and above constituted the remaining 11.7%.

Table 1. Gender and age distribution of household survey respondents in Oforikrom, Kumasi.

| Variable | Category | Frequency | Percent |
|---|---|---|---|
| **Gender** | Male | 55 | 53.4% |
| | Female | 48 | 46.6% |
| **Age Group** | 18–25 | 22 | 21.4% |
| | 26–35 | 26 | 25.2% |
| | 36–45 | 43 | 41.7% |
| | 46–55 | 8 | 7.8% |
| | 56 and above | 4 | 3.9% |
| **Total** | | **103** | **100.0%** |

Regarding length of residence, 33.0% of respondents had lived in the community for more than six years, with 35.9% residing there for over a decade. This indicates deep familiarity with local environmental conditions, making them credible informants for assessing long-term implications of gas station activities. Traders formed the largest occupational group (39.8%), suggesting that many respondents are community-based and directly exposed to environmental disruptions from nearby stations.

### *Environmental challenges reported by communities*

Respondents were asked to identify the environmental challenges they associated with nearby gas filling stations. Table 2 presents the distribution of responses. Air pollution emerged as the dominant concern, with 73.8% (n = 76) of respondents citing it as a primary issue. Noise pollution followed, identified by 9.7% (n = 10) as a major concern. A notable proportion (7.8%, n = 8) reported combined effects of air and noise pollution. Water and soil contamination were mentioned by only 1.9% (n = 2) of respondents, while the remaining 6.8% cited various combinations of air, noise, water, and fire-related issues.

Table 2. Perceived environmental challenges about gas filling stations in Oforikrom, Kumasi.

| Environmental Challenges | Frequency | Percent |
|---|---|---|
| Air pollution | 76 | 73.8% |
| Noise pollution | 10 | 9.7% |
| Air and noise pollution | 8 | 7.8% |
| Water and soil contamination | 2 | 1.9% |
| Air, water, and fire hazards | 1 | 1.0% |
| Air, noise, traffic, and fire hazards | 1 | 1.0% |
| Air, water, noise, and fire hazards | 1 | 1.0% |
| Increased traffic congestion | 1 | 1.0% |
| Water, soil, and traffic congestion | 1 | 1.0% |
| Air, water, soil contamination | 2 | 1.9% |
| **Total** | **103** | **100.0%** |

When asked to rate the severity of these environmental challenges, as shown in Table 3, 44.7% (n = 46) of respondents described them as “very severe”, while an additional 22.3% (n = 23) rated them as “severe”. Thus, over two-thirds of the community (67.0%) perceived the environmental impacts as either severe or very severe. Only 13.6% (n = 14) considered the impacts “moderate”, 11.7% (n = 12) “mild”, and only 7.7% (n = 8) described the impacts as “not severe”.

Table 3. Perceived severity of environmental challenges about gas filling stations in Oforikrom, Kumasi.

| Severity Rating | Frequency | Percent |
|---|---|---|
| Very Severe | 46 | 44.7% |
| Severe | 23 | 22.3% |
| Moderate | 14 | 13.6% |
| Mild | 12 | 11.7% |
| Not Severe | 8 | 7.7% |
| **Total** | **103** | **100.0%** |

### *Community awareness of environmental risks*

The study assessed how residents became aware of environmental risks associated with gas stations. Radio was the most frequently cited source of information, reported by 43.7% (n = 45) of respondents. General media (television, newspapers, and radio combined) accounted for 32.0% (n = 33) of responses. Community meetings were mentioned by only 9.7% (n = 10), while formal education from NGOs or government agencies accounted for a mere 1.0% (n = 1). Personal observation as a standalone source was reported by 4.9% (n = 5) of respondents.

When asked about involvement in gas station siting decisions, an overwhelming 87.4% (n=90) of respondents indicated they had never been consulted or involved in any decision-making process regarding the placement of gas stations in their community. Only 3.9% (n=4) reported having been involved, while 8.7% (n=9) were unsure.

### *Observed non-compliance with EPA buffer zone requirements*

A spatial analysis was conducted on a gas filling station located at Anloga Junction in Oforikrom. The EPA mandates a minimum buffer distance of 100 meters between gas filling stations and sensitive land uses, including schools, residential areas, and market centres. Table 4 presents the measured distances and compliance status. The analysis revealed that the station was located approximately 40 meters from a basic school, 55 meters from a residential area, and 35 meters from a market centre. All three measurements fell significantly below the regulatory requirement of 100 meters, indicating non-compliance across all three proximity indicators.

Table 4. Distance of the selected gas filling station from sensitive land uses in relation to the EPA 100 m buffer requirement.

| Sensitive Land Use | Approximate Distance (m) | EPA Standard (m) | Compliance Status |
|---|---|---|---|
| Basic School | 40 | ≥100 | Non-Compliant |
| Residential Area | 55 | ≥100 | Non-Compliant |
| Market Centre | 35 | ≥100 | Non-Compliant |

### *Community perceptions of mitigation and enforcement*

Regarding the effectiveness of mitigation measures, community perceptions diverged from claims made by station management. While a station manager reported conducting quarterly safety trainings and maintaining leak detection systems, residents described infrequent inspections. An assembly member noted that inspections typically occur only after complaints are filed. In penalties for violations, one key informant stated that fines are often perceived as a minor cost of doing business rather than a genuine deterrent.

## Discussion

The finding that 73.8% of respondents perceived air pollution as the main environmental concern indicates that odour and air-quality-related discomfort are the most visible community-level effects of gas filling stations in Oforikrom. This result is consistent with previous studies showing that fuel

storage and dispensing systems may release volatile organic compounds (VOCs) and other pollutants into the surrounding environment (Fetisov et al., 2023). Persistent fuel odours reported by residents also correspond with observations by Hilpert et al. (2015), who noted that hydrocarbon vapours from fuel facilities may affect nearby residential areas. However, since this study did not directly measure VOCs or particulate matter, these findings should be interpreted as perceived air pollution rather than confirmed pollutant exposure. Nevertheless, the high proportion of residents reporting air pollution suggests that gas station operations are strongly associated with local environmental discomfort.

The severity ratings further support this interpretation. More than two-thirds of respondents perceived the environmental impacts as severe or very severe, indicating that the issue is not viewed as minor or occasional by the community. Compared with similar studies conducted in other Ghanaian cities, this perceived burden appears relatively high (Abdulai et al., 2024). One possible explanation is the dense and mixed-use urban structure of Oforikrom, where residential buildings, markets, schools and commercial activities are located close to gas station operations. Such proximity may increase both actual exposure pathways and public concern, especially where odour, traffic, noise and perceived fire risks overlap in daily life. This interpretation is consistent with evidence of rapid built-up expansion in Kumasi, which suggests increasing pressure on urban land, infrastructure placement and environmental planning (Frimpong and Molkenthin, 2021).

In contrast, water and soil contamination were reported by only 1.9% of respondents. This low percentage should not be interpreted as evidence that such risks are absent. Rather, it may reflect the fact that groundwater and soil contamination are less visible to residents than odour or noise. Fei-Baffoe et al. (2024) similarly emphasized that petroleum hydrocarbon contamination may remain unnoticed until it becomes severe or technically investigated. Since underground storage tank leakage and accidental spills may not be immediately detectable by smell or sight, the low level of public reporting may indicate limited technical awareness rather than low environmental risk. This supports the need for professional environmental monitoring, particularly in areas where residents already report unusual water odours but lack access to testing equipment.

The spatial finding is one of the most important results of the study. The selected gas station at Anloga Junction was located only 40 m from a school, 55 m from a residential area and 35 m from a market, all below the EPA's 100 m buffer requirement. This indicates a clear gap between regulatory standards and siting practice. The result also supports Dongzagla et al. (2023), who reported non-adherence to safe-distance guidelines in urban Ghana. The problem therefore appears to be less about the absence of regulations than about weak implementation, monitoring and accountability. Broader analyses of Ghana's oil and gas sector similarly emphasize that institutional quality, transparency and accountability are central to preventing governance failures (Graham et al., 2016). The statement by an assembly member that inspections occur mainly after complaints suggests a reactive enforcement model. Such an approach shifts the burden of detection onto residents, even though affected communities may lack the technical knowledge, institutional access or political influence required to trigger timely regulatory action. This interpretation is further supported by the observation of Obeng-Darko (2019) that regulatory capacity in Ghana is constrained by limited resources and staffing.

The study also highlights an important participation gap. The fact that 87.4% of respondents reported no involvement in siting decisions suggests a top-down planning process that limits

community influence over local environmental risks. This is contrary to participatory planning principles and may contribute to mistrust, resentment and reduced confidence in regulatory institutions (Bishoge et al., 2019; Mehaffy et al., 2019). In addition, awareness of chronic health risks appears limited. While residents may be alert to immediate fire hazards, the long-term risks associated with repeated low-level exposure to fuel-related emissions seem less understood. The reliance on radio and general media as dominant information sources, combined with the very limited role of formal education programmes, indicates a missed opportunity for targeted public risk communication (Crentsil et al., 2019). Community durbars and local-language radio programmes may therefore provide culturally appropriate channels for improving awareness and encouraging public participation.

Overall, the findings indicate an implementation gap in Ghana's gas station regulatory framework. Legal standards exist, but enforcement, community consultation and environmental monitoring remain insufficient. This has environmental justice implications, as communities such as Oforikrom may bear a disproportionate share of risks associated with non-compliant infrastructure. However, the findings should be interpreted within the limitations of the study. The analysis was based mainly on community perceptions and did not include direct measurements of air, water, soil or noise pollution. Spatial compliance was assessed for only one purposively selected station and cannot be generalized to all gas stations in Kumasi. The cross-sectional design also captures perceptions at a single point in time. Future studies should therefore combine representative spatial assessment with direct environmental monitoring and longitudinal community data.

## Conclusions

This study evaluated community perceptions of environmental hazards associated with gas filling stations in Kumasi and assessed the spatial compliance of a selected station with EPA buffer zone requirements. The findings indicate a considerable gap between regulatory standards and the lived reality of residents in Oforikrom. Although gas stations provide an essential energy service for a growing urban population, many residents perceived them as sources of environmental concern, particularly due to fuel odours and air pollution. More than two-thirds of respondents rated the impacts as severe or very severe, while 87.4% reported that they had not been consulted in station siting decisions. The distance analysis at Anloga Junction further showed non-compliance with the EPA-required 100 m buffer zone, with the station located 40 m from a school, 55 m from a residential area and 35 m from a market. These findings suggest the need for stronger spatial planning, regular enforcement, community participation and targeted public awareness on both fire safety and chronic exposure risks. Since this study did not directly measure pollution levels, future research should include environmental monitoring of air, water and soil quality across a wider sample of gas stations.

## Author Contributions

The authors performed all the experiments and drafted the main manuscript text. All authors reviewed and approved the final version of the manuscript.

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**Conflict of Interest Statement**

The authors declare that for this article they have no actual, potential or perceived conflict of interest.

**Ethical Approval Statement**

Ethical approval for this study was obtained from the Kwame Nkrumah University of Science and Technology Committee on Human Research, Publications and Ethics before data collection. All participants were informed about the purpose of the study, the voluntary nature of participation and their right to withdraw at any stage without penalty. Written informed consent was obtained from household survey respondents, while verbal informed consent was obtained from key informants. No personally identifiable information was collected or included in the dataset, and all data were stored securely on a password-protected computer accessible only to the research team.

**Data Availability Statement**

The data used in the present study are available upon request from the corresponding author.

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