

Assessment of the Quality, Health, Safety, and Environment (QHSE) Management System at Petrol Stations in the Mont-Amba District of Kinshasa, Democratic Republic of the Congo

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ABSTRACT

Introduction

The rapid, uncoordinated proliferation of petrol stations poses significant risks to public hygiene, community safety, and environmental integrity within the Mont-Amba district of Kinshasa, Democratic Republic of the Congo (DRC).

Purpose

This study evaluates the Quality, Health, Safety, and Environment (QHSE) management systems operating across petrol stations in Mont-Amba.

Method

A cross-sectional survey identified 49 operational petrol stations. Primary data were gathered using field observation checklists and GPS coordinate mapping. Spatial distribution and buffer distances were analyzed using OpenStreetMap shapefiles, Electoral Commission (CENI) administrative boundaries, and ArcGIS Pro 3.4 tools (Kernel Density Estimation, Euclidean distance, and buffer analysis) projected in Universal Transverse Mercator (UTM Zone 33S/34S).

Results

Compliance rates across the evaluated systems were critically low: 31.9% for hygiene, 23.5% for safety, and 33.0% for environmental standards. High station density and extreme proximity to residential zones (<400 m) heightened the risk of structural fires, localized air pollution, soil contamination, and groundwater degradation. Basic occupational safety requirements—including essential personal protective equipment (PPE)—were systematically neglected.

Conclusion

Substandard QHSE performance across Mont-Amba petrol stations creates severe operational hazards and degrades the urban ecosystem. Enforcing strict regulatory oversight, mandatory Environmental and Social Impact Assessments (ESIAs), and minimum spatial buffer zones is essential to mitigate these public health risks.

INTRODUCTION

The expansion of the automotive sector has driven steady growth in retail fuel distribution infrastructure (Ozer & Perrin, 2014). Since the early twentieth century, service stations have become integral components of urban transportation networks and primary hubs for fuel and lubricant distribution (Makanzu, 2014). However, when managed without strict safety controls, storing and handling highly flammable liquid hydrocarbons creates acute operational hazards (Munduku et al., 2024). Despite these inherent risks, retail fuel distribution expanded rapidly across developing nations as an accessible economic activity (Mutungu, 2014).

Across urban Africa, fuel distribution systems face unique challenges driven by population growth, grid instability, and the widespread use of diesel generators and motorcycle taxis (Lelo Nzuzi, 2017; Mpuru, 2025). Historically constrained fuel supply chains have given way to decentralized, high-density retail networks (Manirakiza, 2009). Petrol stations now represent prominent fixtures in the built environment (Kikozoko et al., 2021; Tshibangu, 2020). However, the uncoordinated proliferation of these facilities—frequently operating without comprehensive Environmental and Social Impact Assessments (ESIAs)—exposes adjacent communities to severe risks, including catastrophic fires, acute airborne pollution, soil contamination, and severe traffic congestion (Mpuru, 2024; Musibono, 2015; Ozer, 2020).

In the Mont-Amba district of Kinshasa, retail stations are increasingly integrated into dense commercial and residential neighborhoods (Lelo Nzuzi, 2011). Fast-food vendors, convenience stores, and informal markets routinely cluster around pump forecourts, expanding the population exposed to potential incidents. Despite these compounding hazards, systematic spatial and empirical audits of Quality, Health, Safety, and Environment (QHSE) compliance remain absent in Mont-Amba.

This study addresses two primary research questions:

1. What structural and operational factors drive the low compliance of QHSE management systems in the Mont-Amba district?

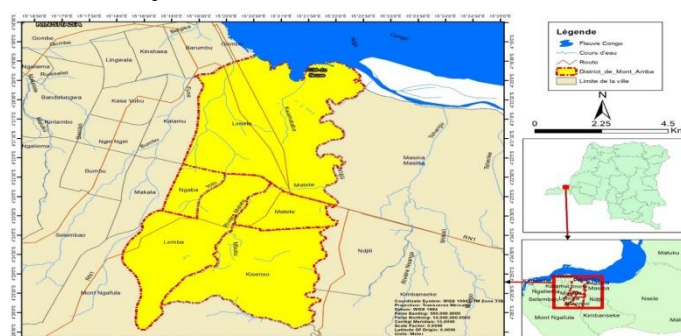
2. What are the measurable performance levels of local petrol stations regarding standard hygiene, safety, and environmental criteria?
3. The primary objective is to evaluate the functional status and compliance rates of QHSE management systems across service stations in Mont-Amba, identifying specific structural deficiencies to inform local regulatory policy.

METHODS

Study Area

This investigation was conducted in the Mont-Amba district of Kinshasa, Democratic Republic of the Congo. Covering 116.88 km² around 4° 21' 46" S and 15° 20' 12" E, Mont-Amba is one of four primary administrative districts comprising the city-province of Kinshasa alongside Funa, Lukunga, and Tshangu (Shomba et al., 2015). The district encompasses five municipalities (Lemba, Limete, Ngaba, Matete, and Kisenso) divided into roughly 60 sub-neighborhoods (Figure 1).

Figure 1:
Administrative map of the Mont-Amba district within Kinshasa



Study Design and Data Collection

A cross-sectional observational audit was conducted using individual petrol stations as primary statistical units (N = 49). Quantitative and qualitative indicators were assessed using standardized observation checklists structured across three performance domains:

- i. Hygiene Management System (HMS)
- ii. Occupational Health and Safety (OHS)
- iii. Environmental Management System (EMS)

Spatial position data were gathered at each forecourt using a Garmin GPS device (WGS 84 datum, UTM Zone 33S projection). Photographic evidence was collected

using a high-resolution mobile sensor (Techno Camon 30) to document physical hazards, forecourt encroachment, and traffic congestion.

Spatial and Statistical Analysis

Spatial parameters were analyzed in ArcGIS Pro 3.4 using OpenStreetMap vector basemaps and CENI administrative shapefiles. Spatial density and proximity patterns were modeled using Kernel Density Estimation (KDE), Euclidean distance calculations, and concentric buffer generation (100 m to 1,000 m).

Compliance rates (C_R) for each QHSE domain were calculated using **Equation 1**:

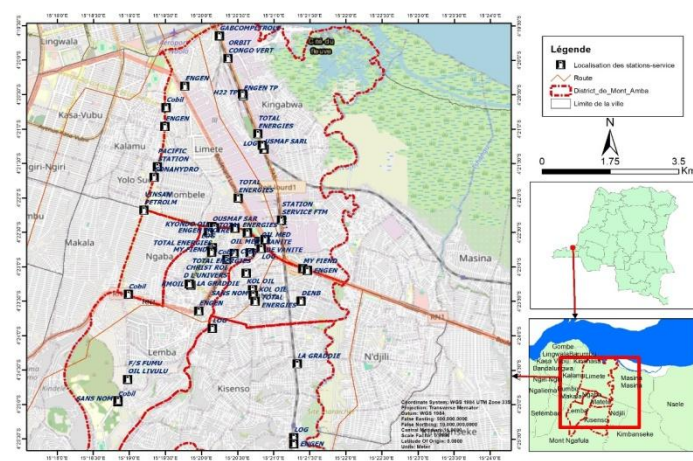
$$C_R = \left(\sum y_i / N_{\text{total}} \right) \times 100$$

Where y_i represents a positive compliance finding ("Yes") for item i , and N_{total} represents the total number of evaluated items across all sampled stations ($N \times \text{number of domain indicators}$).

RESULTS

Field mapping identified 49 operational petrol stations distributed along major transport corridors in Mont-Amba (**Figure 2**).

Figure 2:
Geolocation and distribution of operational petrol stations in Mont-Amba



Hygiene Management System Performance

Assessment of hygiene indicators revealed severe structural deficiencies across all operational units (**Table 1**).

Table 1:
Performance indicators for hygiene management systems (N = 49)

Performance Indicator	Compliant (Yes)	Non-Compliant (No)	Compliance Rate (%)
Hygiene Plan	6	43	12.2%
Facility Maintenance Plan	24	25	49.0%
Pest Control Plan	20	29	40.8%
Dedicated Hand-Washing Facilities	0	49	0.0%
Accessible Public Toilets	30	19	61.2%
Standard First-Aid Kit	14	35	28.6%
Total Indicators Evaluated (N=294)	94	200	31.9%

Overall hygiene compliance reached only 31.9%. None of the sampled stations possessed dedicated hand-washing stations, and only 12.2% maintained a formal hygiene plan.

Occupational Health and Safety (OHS) Performance

Safety audits demonstrated widespread non-compliance with elementary OHS norms (**Table 2**).

Table 2:
Performance indicators for occupational health and safety systems (N = 49)

Safety Performance Indicator	Compliant (Yes)	Non-Compliant (No)	Compliance Rate (%)
Formal Safety Plan	0	49	0.0%
Visual Safety Signage Plan	4	45	8.2%
Structural Guardrails Installed	35	14	71.4%
Attendants Wear Respiratory Masks	0	49	0.0%
Attendants Wear Safety Goggles	0	49	0.0%
Attendants Wear Protective Gloves	0	49	0.0%
Attendants Wear Safety Footwear	15	34	30.6%
Attendants Wear Standard Overalls	0	49	0.0%
Forecourt Speed Bumps Installed	4	45	8.2%
Serviced Fire Extinguishers Present	40	9	81.6%
Minimum Inter-Station Distance ≥ 1 km	13	36	26.5%
Minimum Residential Setback Distance	1	48	2.0%
Operational Safety Warning System	6	43	12.2%
Standardized Forecourt Lighting	30	19	61.2%
Hydrocarbon Spill Containment Kits	30	19	61.2%
Emergency Fuel Cut-Off Systems	6	43	12.2%
Active CCTV Surveillance Cameras	12	37	24.5%
Total Indicators Evaluated (N=833)	196	637	23.5%

The aggregate OHS compliance rate was 23.5%. Personal protective equipment (PPE) compliance was essentially non-existent: no station supplied workers with masks, eye protection, protective gloves, or standard flame-retardant overalls. Only a single station met municipal setback distances from residential properties.

Euclidean distance calculations showed that 73.5% ($n = 36$) of stations were situated within 400 m of a neighboring facility (**Figure 3**), creating clustered fire hazard zones in the municipality of Lemba (**Figure 4**).

Figure 3:
Euclidean distance buffer map indicating spatial proximity between adjacent petrol stations

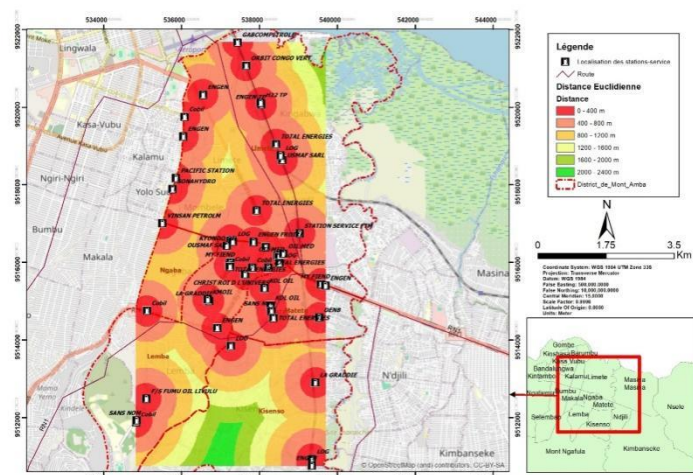
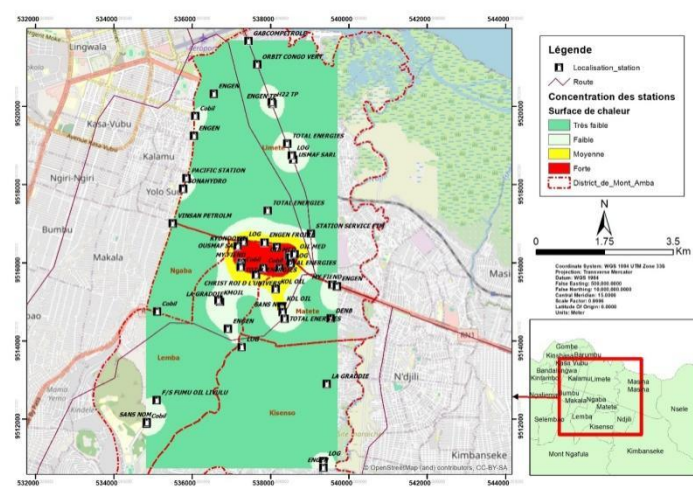
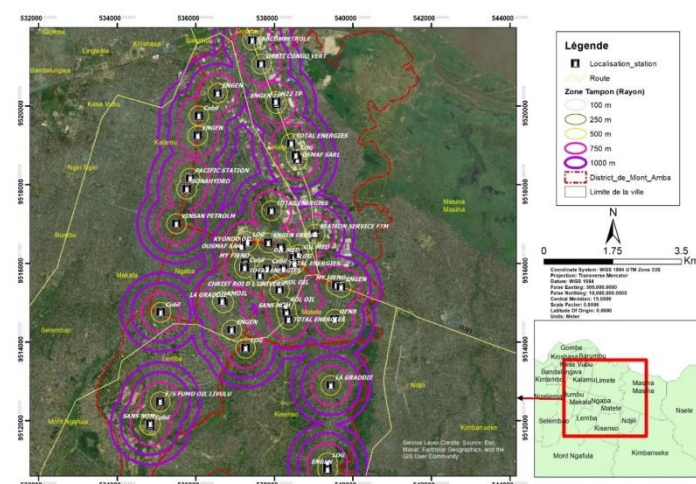


Figure 4:
Kernel density heat map highlighting high-concentration petrol station clusters in Lemba



No surveyed stations operated effluent treatment plants, active vapor recovery mechanisms, or ambient air monitoring systems.

Figure 5:
Spatial impact zones showing overlapping radii (100 m to 1,000 m) surrounding retail facilities



Field investigations documented severe visual, physical, and operational hazards. Forecourt congestion routinely disrupted major thoroughfares (Photo 1), while abandoned vehicles occupied pump access routes (Photo 2). Furthermore, several pump dispensers were constructed immediately adjacent to high-density, multi-story residential structures (Photo 3).

Photos 1-3:
Representative forecourt hazards in Mont-Amba: severe vehicle congestion at Super Lemba (left); abandoned vehicles blocking forecourt lanes at 'La Grandie Lemba' (center); fuel pumps positioned directly adjacent to residential housing (right)



Environmental Management System Performance
Environmental compliance indicators recorded an aggregate score of 33.0% (Table 3).

Table 3:
Performance indicators for environmental management systems (N = 49)

Environmental Indicator	Compliance		Compliance Rate (%)
	Compliant (Yes)	Non-Compliant (No)	
Liquid Effluent Treatment Systems	0	49	0.0%
Solid Waste Storage Management	30	19	61.2%
Vegetated Green Belt / Buffer	25	24	51.0%
Designated Emergency Assembly Point	35	14	71.4%
Soil Contamination Prevention Protocols	20	29	40.8%
Groundwater Protection Protocols	20	29	40.8%
Air Quality Monitoring Measures	0	49	0.0%
Active Vapor Recovery Systems	0	49	0.0%
Total Indicators Evaluated (N=392)	130	262	33.0%

Photo 2



Photo 3



DISCUSSION

The presence of 49 operational stations within Mont-Amba underscores widespread regulatory drift in Kinshasa's urban planning framework. These spatial patterns align with findings by Lelo Nzuzi (2017), who demonstrated that weak municipal oversight leads to uncoordinated commercial construction without prior ESIs. Omitting preliminary scientific and environmental impact studies when siting hazardous infrastructure compromises community safety and weakens urban resilience (Mpuru, 2024; Musibono, 2015).

The measured hygiene compliance rate (31.9%) falls well below the 75.0% threshold established by Nouhou (2019) as the minimum baseline required to safeguard public health in commercial facilities. Deficiencies in basic sanitation transform fuel station forecourts into vector transmission zones, threatening workers, commuters, and nearby residents while exposing station owners to reputational and financial liability (Munduku et al., 2024).

Similarly, the overall OHS performance score (23.5%) illustrates systemic labor rights and safety violations across the sub-Saharan fuel retail sector (Antoine-Moussiaux et al., 2023). International technical specifications, such as ISO 16923 (2016), mandate minimum isolation distances of 1 km between retail stations handling volatile fuels. In Mont-Amba, over 70% of stations operate within 400 m of competing facilities. This spatial concentration creates severe domino-effect risks, where a single fire or vapor explosion could trigger catastrophic chain-reaction incidents in densely populated residential blocks.

Study Strengths & Policy Implications:

This study offers the first spatially integrated, empirical audit of station-level QHSE performance in the Mont-Amba district. By combining field observations with GIS spatial analysis, these findings establish a clear empirical foundation for urban planning authorities to enforce existing environmental codes and mandate minimum safety buffers across Kinshasa.

CONCLUSION

The retail fuel distribution sector in the Mont-Amba district operates under dangerously low QHSE standards, recording compliance rates of 31.9% for hygiene, 23.5% for occupational safety, and 33.0% for environmental protection. High spatial density, minimal separation distances (<400 m), lack of protective equipment, and absent effluent and vapor controls together pose acute risks to local populations and urban ecosystems.

Municipal authorities must immediately freeze approvals for unzoned retail fuel facilities, enforce statutory urban planning standards (ISO 16923), and compel operational facilities to conduct retroactive ESIs. Future research should prioritize biomonitoring of organic volatile exposure (e.g., benzene, toluene) among forecourt attendants and hydrogeological assessments of local water tables to detect subsurface hydrocarbon migration.

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Data Availability Statement: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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