Faculty of Natural and Applied Sciences Journal of Basic and Environmental Research
Print ISSN: 3026-8184 e-ISSN 3043-6338
www.fnasjournals.com
Volume 2; Issue 1; September 2024; Page No. 10-18.

Evaluation and Analysis of the Impact of Emissions from Slaughterhouses

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Abstract
This study investigates air quality around slaughterhouses in Port Harcourt, South-South Nigeria, focusing on the concentrations of various air pollutants. The study employs a completely randomized block design to collect air quality data from five slaughterhouse locations over twelve months. Parameters including nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), volatile organic compounds (VOC), methane (CH_4), hydrogen sulphide (H2S), and ammonia (NH_3) were measured using handheld air quality monitoring equipment. Results indicate higher concentrations of air pollutants in the morning compared to the evening, with values often exceeding World Health Organization (WHO) standards. Specifically, sulphur dioxide (SO_2) levels were highest at the Rumuokoro slaughterhouse, while nitrogen dioxide (NO_2) concentrations peaked at the Eleme slaughterhouse. Carbon monoxide (CO) levels were highest at the Trans Amadi slaughterhouse, while volatile organic compounds (VOCs) showed elevated levels at the Eagle Island slaughterhouse. Methane (CH4) and hydrogen sulphide (H_2S) levels were particularly high at the Rumuokoro slaughterhouse. Ammonia (NH3) concentrations were highest at the Eleme slaughterhouse. Overall, the study highlights significant air pollution around slaughterhouse facilities, exceeding permissible limits and posing potential health and environmental risks to nearby communities. Urgent measures are recommended to mitigate pollution and promote sustainable practices in slaughterhouse operations to safeguard public health and the environment.

Keywords: Slaughterhouse Air Pollution, Pollutant Concentrations, WHO Standards, Environmental Risks, Health Implications

Introduction

Slaughterhouses play a vital role in the food industry, serving as facilities where animals are processed and meat products are prepared for consumption. Throughout history, societies worldwide have recognized the importance of slaughterhouses in meeting the dietary needs of their populations. These facilities are designed not only for the efficient slaughter of animals but also for the proper handling, processing, and distribution of meat products to ensure food safety and hygiene standards are met (Faribal et al., 2012). The construction and operation of slaughterhouses are subject to stringent regulations and standards set by government authorities. Ensuring compliance with these regulations is essential for maintaining the integrity of the food supply chain and safeguarding public health. The atmosphere surrounding slaughterhouses contains a diverse mixture of gases, including nitrogen, oxygen, argon, carbon dioxide, and trace gases such as methane and nitrous oxides. While these gases are naturally occurring and essential components of the atmosphere, their concentrations can fluctuate based on various factors, including location, time of day, and weather conditions. Of particular concern are greenhouse gases like carbon dioxide and methane, which have the potential to alter the Earth's climate and impact the global energy balance (Ichinose et al., 2011).

In addition to their role in food production, slaughterhouses also generate waste materials, including manure and other by-products, which can pose environmental challenges. The management of these wastes is critical to preventing air and water pollution, as well as minimizing the emission of greenhouse gases such as methane and nitrous oxide (Adeyemi & Adeyemo, 2007). Despite the importance of addressing the environmental impact of slaughterhouses, there is limited research available on greenhouse gas emissions from these facilities, particularly in regions where livestock production is prevalent, such as Africa. This gap in knowledge underscores the need for comprehensive studies to evaluate and analyze the impact of gases emitted from slaughterhouses on the environment and public health

Cite this article as:
Maduforoh, C., & Horsfall, E.O. (2024). Evaluation and analysis of the impact of emissions from slaughterhouses. *FNAS Journal of Basic and Environmental Research*,*2*(1), 10-18.

(Ware & Power, 2016). This study focuses on assessing the impact of gases in slaughterhouses in Port Harcourt, South-South Nigeria, to provide valuable insights into the environmental implications of these facilities and inform the development of sustainable management practices. By understanding the sources and effects of greenhouse gas emissions from slaughterhouses, stakeholders can work towards mitigating their environmental footprint and promoting the sustainable production of meat products.

Methodology

The study was conducted in Port Harcourt, located in the South-South region of Nigeria. Five slaughterhouse locations were selected for the study, namely Trans-Amadi slaughterhouse (04°48'53"N, 07°02'42"E), Eleme (04°95'43.92"N, 07°01'26.25"E), Rumuokoro (04°65'43.69"N, 07°01'31.70"E), Eagle-Island (04°47'39"N, 06°58'25"E), and Okuru (04°47'39"N, 07°58'45"E). The experimental design employed in this investigation was the completely randomized block design, following the principles of replication and randomization (Zar, 1984). Although the study sites were purposefully chosen, the design ensured the distribution of experimental units into homogeneous groups or blocks of equal size, with treatments assigned randomly within each block. This approach minimizes the influence of external factors on the collected data. Air quality testing was conducted at each slaughterhouse to measure seven gas parameters: nitrogen dioxide (NO2), carbon monoxide (CO), sulfur dioxide (SO2), volatile organic compounds (VOC), methane (CH4), hydrogen sulfide (H2S), and ammonia (NH3). Hand-held air quality monitoring equipment was used for data collection. Samples were collected from the Trans-Amadi slaughterhouse (04°48'53"N, 07°02'42"E), as well as the Eleme (04°95'43.92"N, 07°01'26.25"E), Rumuokoro (04°65'43.69"N, 07°01'31.70"E), Eagle-Island (04°47'39"N, 06°58'25"E), and Okuru (04°47'39"N, 07°58'45"E) slaughterhouses. Data on gas pollutants were collected in both morning and evening periods over a twelve-month period (February 2020 to January 2021). Air quality sampling was performed using a hand-held air quality monitor powered by a dry cell battery. The AeroQual Air Analyzer, Series500, was utilized to determine the concentration of various air parameters and suspended particulates within the slaughterhouses.

Results

Air Quality Analysis for Air Pollutant Gases The results obtained from the slaughterhouses for air pollutant gases (SO_2, NO_2, CO, VOC, CH_4, H_2S, and NH_3) in both morning and evening periods revealed higher values in the morning compared to the evening. Bar charts depicting the mean ± standard deviation concentrations of air pollutant gases at the five research sites (Trans-Amadi, Eleme, Rumuokoro, Eagle-Island, and Okuru slaughterhouses) during morning and evening periods are presented in Figures 1-7 in the Appendix.

Table.1: Mean ±SD concentrations of SO_2 (μg/m^3) in the various slaughterhouses in the morning and evening.

Location (Study Area)	Mean Morning	Mean Evening	Standard Deviation Morning	Standard Deviation Evening	Coefficient Of Variation Morning	Coefficient Of Variation Evening	Standard Error Morning	Standard Error Evening
TRANS AMADI	0.329	0.243	0.071	0.031	21.58	11.18	0.0017	0.0011
ELEME	0.341	0.211	0.111	0.101	34.69	21.69	0.0041	0.0021
RUMUOKORO	0.471	0.271	0.268	0.218	57.02	17.02	0.0240	0.0210
EAGLE ISLAND	0.362	0.212	0.087	0.017	24.03	14.03	0.0025	0.0012
OKURU	0.170	0.110	0.056	0.016	15.30	12.30	0.0005	0.0003

Table 2: Mean±SD concentrations of NO_2 (μg/m^3) in the various slaughterhouses in the morning and evening.

Location (Study Area)	Mean Morning	Mean Evening	Standard Deviation Morning	Standard Deviation Evening	Coefficient Of Variation Morning	Coefficient Of Variation Evening	Standard Error Morning	Standard Error Evening
TRANS AMADI	0.997	0.514	0.134	0.113	17.16	11.16	0.0029	0.0021
ELEME	1.071	0.814	0.178	0.114	19.10	12.10	0.0049	0.0011
RUMUOKORO	0.987	0.513	0.130	0.111	16.20	12.20	0.0026	0.0010
EAGLE ISLAND	0.913	0.602	0.123	0.104	14.42	11.42	0.0024	0.0011
OKURU	0.545	0.313	0.093	0.025	5.34	1.34	0.0018	0.0012

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Table.3: Mean±SD concentrations of CO (μg/m^3) in the various slaughterhouses in the morning and evening.

Location (Study Area)	Mean Morning	Mean Evening	Standard Deviation Morning	Standard Deviation Evening	Coefficient Of Variation Morning	Coefficient Of Variation Evening	Standard Error Morning	Standard Error Evening
TRANS AMADI	0.996	0.516	0.327	0.245	18.76	12.76	0.0082	0.0012
ELEME	0.875	0.415	0.295	0.225	16.74	12.74	0.0073	0.0013
RUMUOKORO	0.789	0.419	0.243	0.223	15.32	11.32	0.0063	0.0013
EAGLE ISLAND	0.832	0.312	0.289	0.229	16.54	11.54	0.0071	0.0011
OKURU	0.654	0.214	0.205	0.215	14.45	11.45	0.0042	0.0012

Table 4: Mean±SD concentrations of VOC (μg/m^3) in the various slaughterhouses in the morning and evening.

Location (Study Area)	Mean Morning	Mean Evening	Standard Deviation Morning	Standard Deviation Evening	Coefficient Of Variation Morning	Coefficient Of Variation Evening	Standard Error Morning	Standard Error Evening
TRANS AMADI	625.149	325.119	12.492	10.432	20.253	10.253	10.080	10.010
ELEME	648.411	348.401	13.643	11.633	27.425	17.225	11.436	10.012
RUMUOKORO	625.867	325.817	12.345	10.315	25.892	15.892	10.865	10.030
EAGLE ISLAND	658.209	358.109	14.492	11.412	26.235	12.235	12.543	11.313
OKURU	571.309	271.109	9.457	7.457	10.549	8.099	8.081	6.011

Table 5: Mean±SD concentrations of CH_4 (μg/m^3) in the various slaughterhouses in the morning and evening.

Location (Study Area)	Mean Morning	Mean Evening	Standard Deviation Morning	Standard Deviation Evening	Coefficient Of Variation Morning	Coefficient Of Variation Evening	Standard Error Morning	Standard Error Evening
TRANS AMADI	0.321	0.211	0.201	0.111	28.58	12.58	0.0027	0.0017
ELEME	0.311	0.201	0.115	0.115	34.69	12.69	0.0021	0.0011
RUMUOKORO	0.412	0.112	0.148	0.128	57.02	11.02	0.0040	0.0010
EAGLE ISLAND	0.314	0.114	0.117	0.107	24.03	12.03	0.0025	0.0015
OKURU	0.164	0.112	0.046	0.026	15.30	11.30	0.0015	0.0015

Table 6: Mean±SD concentrations of H_2S **(μg/m^3) in the various slaughterhouses in the morning and evening.**

Location (Study Area)	Mean Morning	Mean Evening	Standard Deviation Morning	Standard Deviation Evening	Coefficient Of Variation Morning	Coefficient Of Variation Evening	Standard Error Morning	Standard Error Evening
TRANS AMADI	0.912	0.502	0.333	0.213	18.18	11.18	0.0064	0.0014
ELEME	0.814	0.404	0.277	0.117	16.21	10.21	0.0053	0.0013
RUMUOKORO	0.726	0.316	0.212	0.102	15.16	12.16	0.0046	0.0016
EAGLE ISLAND	0.818	0.408	0.279	0.219	16.22	12.22	0.0052	0.0012
OKURU	0.698	0.218	0.208	0.109	14.31	11.31	0.0030	0.0010

Table 7: Mean±SD concentrations of NH_3 (μg/m^3) in the various slaughterhouses in the morning and evening.

Location (Study Area)	Mean Morning	Mean Evening	Standard Deviation Morning	Standard Deviation Evening	Coefficient Of Variation Morning	Coefficient Of Variation Evening	Standard Error Morning	Standard Error Evening
TRANS AMADI	0.886	0.416	0.131	0.111	16.75	11.75	0.0035	0.0015
ELEME	0.933	0.411	0.145	0.115	17.23	11.23	0.0051	0.0011
RUMUOKORO	0.889	0.416	0.135	0.115	16.79	12.79	0.0039	0.0019
EAGLE ISLAND	0.882	0.422	0.125	0.115	16.70	12.70	0.0034	0.0014
OKURU	0.654	0.324	0.100	0.008	14.34	11.34	0.0029	0.0019

Discussion

In the morning and evening, air pollutant levels varied significantly across Trans Amadi, Eleme, Rumuokoro, Eagle Island, and Okuru slaughterhouses. The study assessed air quality by measuring mean ± standard deviation (SD) values of ammonia (NH_3), carbon monoxide (CO), hydrogen sulfide (H_2S), methane (CH_4), nitrogen dioxide (NO2), sulfur dioxide (SO_2), and volatile organic compounds (VOCs). In Table 1, the morning and evening concentrations of SO_2 at each slaughterhouse are displayed. SO2 levels peaked at Rumuokoro and were lowest at Okuru slaughterhouse consistently throughout both time periods. Concentrations ranged from 0.471±0.268 to 0.170±0.056 μg/m3 in the morning and 0.271±0.218 to 0.110±0.016 μg/m3 in the evening. These values surpassed WHO standards, signalling potential health hazards. In Table 2, you'll find the morning and evening levels of NO_2 at each slaughterhouse. Eleme showed the highest concentrations, while Okuru had the lowest. In the mornings, levels ranged from 1.071±0.178 to 0.545±0.093 μg/m3, and in the evenings, from 0.811±0.118 to 0.315±0.023 μg/m3. These high NO_2 levels can lead to smog formation and respiratory issues, posing health concerns for nearby communities. In Table 3, you'll see the morning and evening CO levels. They were highest at Trans Amadi and lowest at Okuru. During the mornings, they ranged from 0.996±0.327 to 0.654±0.205 μg/m3, and in the evenings, from 0.516±0.245 to 0.214±0.215 μg/m3. CO, a byproduct of incomplete combustion, poses risks to both our health and the environment. In Table 4, you'll find the VOC concentrations. Eagle Island had the highest levels, while Okuru had the lowest. During the morning, concentrations ranged from 658.209±14.492 to 571.309±9.457 μg/m3, and in the evening, from 358.109±14.412 to 271.109±9.457 μg/m3. VOCs play a role in ozone formation and can lead to various health problems.

Let us talk about methane (CH_4) and hydrogen sulfide (H_2S) concentrations. Table 5 lays out the CH_4 levels, while Table 6 gives us the H2S levels. Rumuokoro had the highest CH_4 levels, and Trans Amadi topped the charts for H_2S. It's concerning that both gases exceeded WHO standards, posing risks to both our health and the environment. Similarly, for ammonia (NH_3) concentration, Table 7 tells us that NH_3 levels were highest at Eleme and Eagle Island. In the morning, concentrations ranged from 0.933±0.145 to 0.654±0.100 μg/m3, and in the evening, from 0.422±0.115 to 0.324±0.100 μg/m3. NH3's impact on acid deposition and eutrophication affects ecosystems and human health alike. It is alarming that all slaughterhouses exceeded WHO standards for various pollutants. This indicates severe environmental problems, with elevated pollutant levels leading to respiratory issues, acid deposition, and ecosystem damage. Industrial activities like tyre combustion and emissions from oil servicing companies significantly contribute to the pollution levels in the area.

Conclusion

It was observed that in the morning, levels were generally higher than evenings. Sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), volatile organic compounds (VOCs), methane (CH_4), hydrogen sulfide (NH_3), and ammonia (NH_3) were all found to exceed World Health Organization (WHO) standards, indicating severe environmental and health risks. The presence of these pollutants poses a range of health concerns, including respiratory issues, cardiovascular problems, and neurological disorders. Furthermore, pollutants such as NO_2 and VOCs contribute to the formation of smog and ozone, exacerbating air quality issues and increasing the risk of respiratory ailments. Additionally, elevated levels of methane and hydrogen sulfide can lead to explosions and pose serious safety hazards to workers and nearby residents. The study also highlights the role of industrial activities, such as tyre combustion and emissions from oil servicing companies, in contributing to air pollution in the area. These findings underscore the need for comprehensive regulatory measures and pollution control strategies to mitigate emissions from slaughterhouse operations and industrial sources. Such measures may include improved waste management practices, the use of cleaner technologies, and stricter enforcement of environmental regulations. This study underscores the urgent need for action to address air pollution in slaughterhouse environments and protect public health. Collaborative efforts involving government agencies, industry stakeholders, and local communities are essential to develop and implement effective pollution control measures. Failure to address these issues could have serious consequences for both human health and the environment in affected areas.

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Appendices

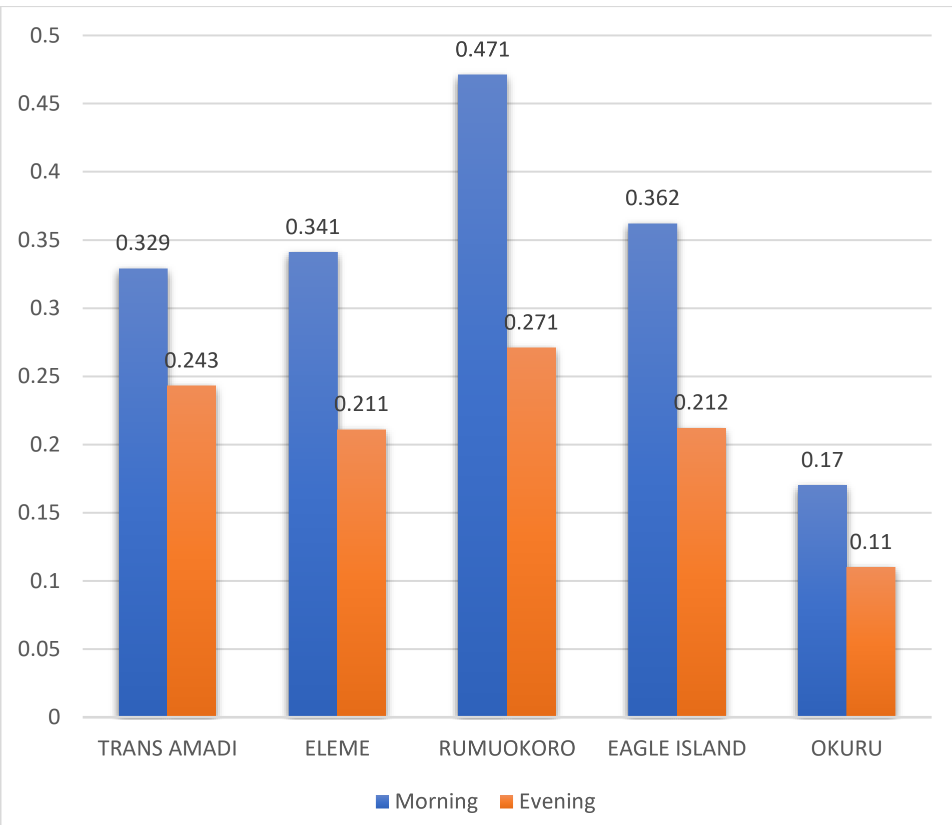

Fig.1: Mean concentrations of SO_2 (µg/m^3) in the various slaughterhouses in the morning and evening.

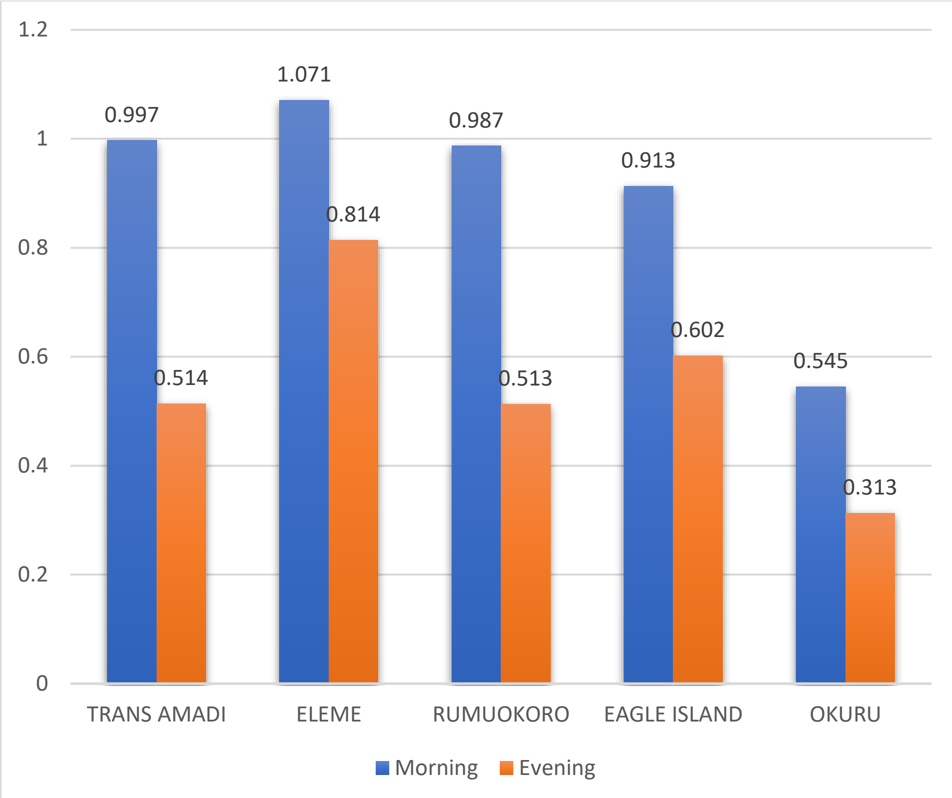

Fig.2: Mean concentration of NO_2 (μg/m^3) in the various slaughterhouses in the morning and evening.

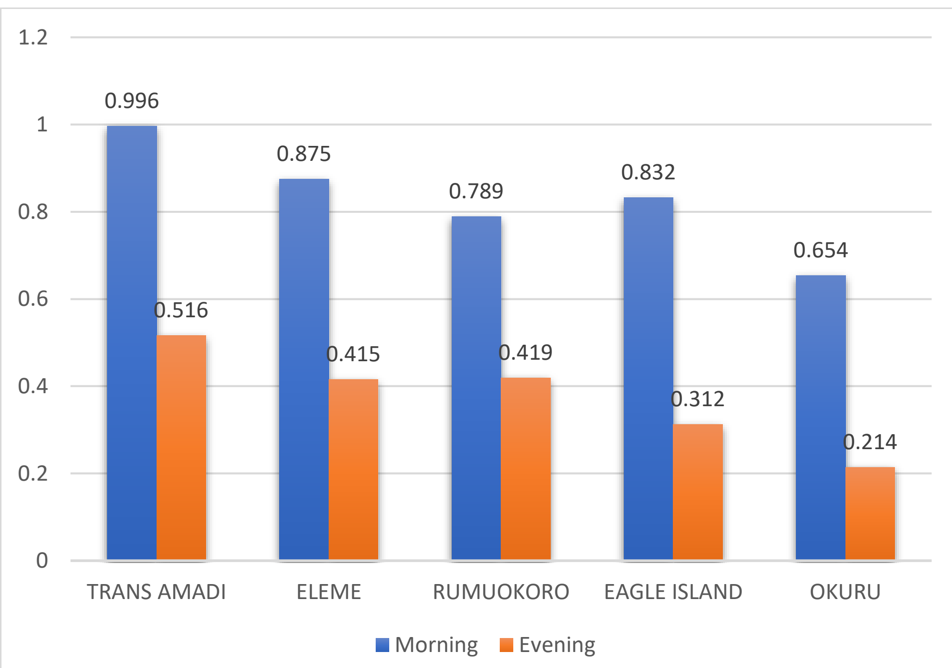

Fig.3: Mean concentrations of CO (μg/m^3) in the various slaughterhouses in the morning and evening.

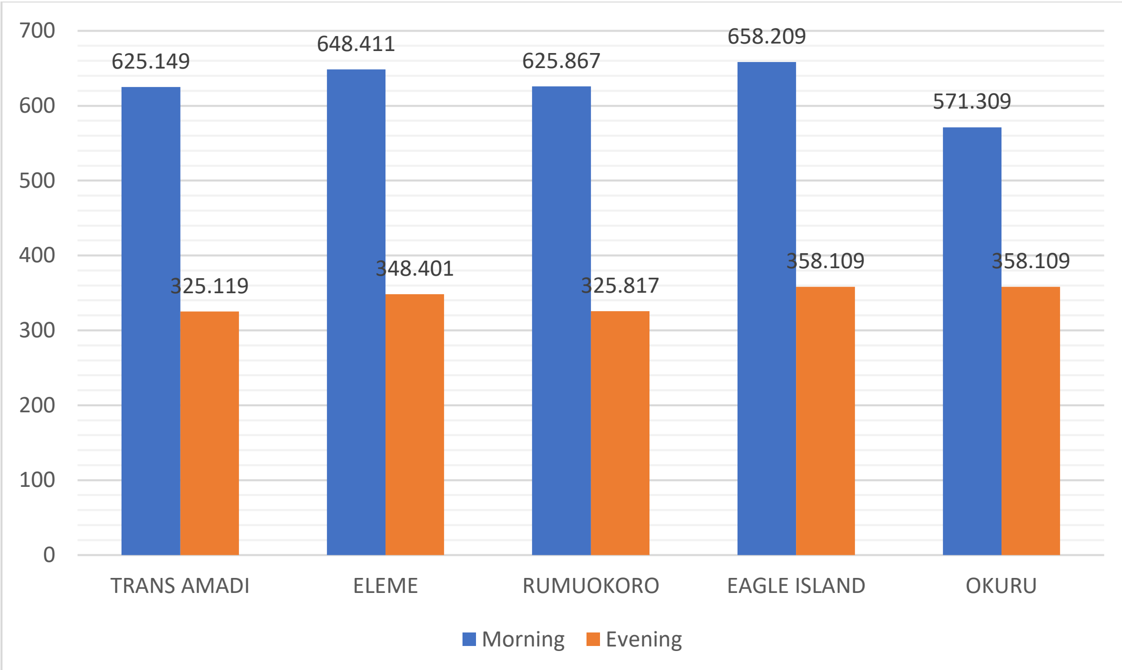

Fig.4: Mean concentrations of VOC (μg/m^3) in the various slaughterhouses in the morning and evening.

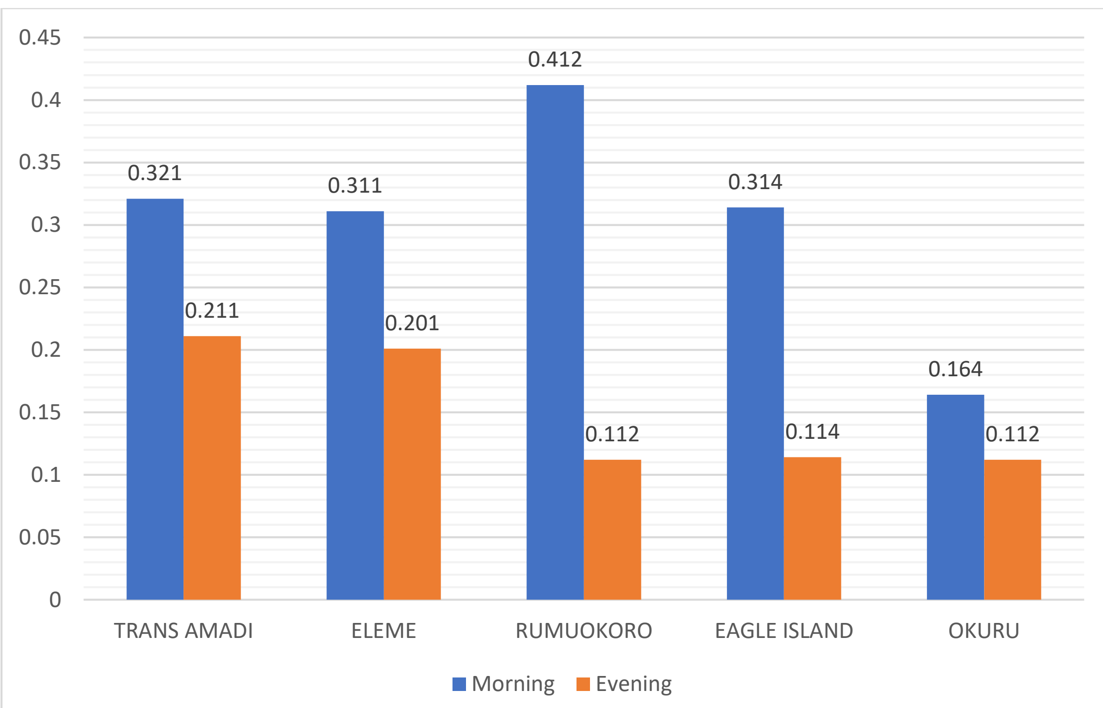

Fig.5: Mean concentrations of CH_4 (μg/m^3) in the various slaughterhouses in the morning and evening.

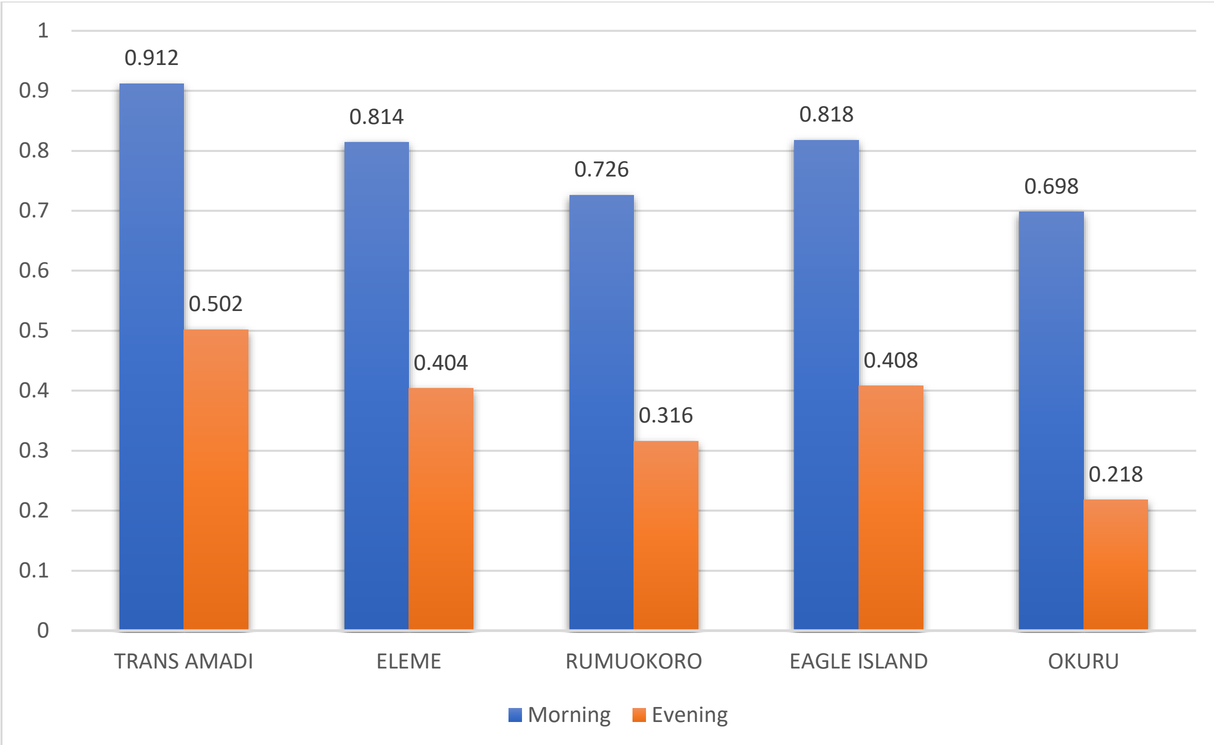

Fig.6: Mean±SD concentrations of H_2S (μg/m^3) in the various slaughterhouses in the morning.

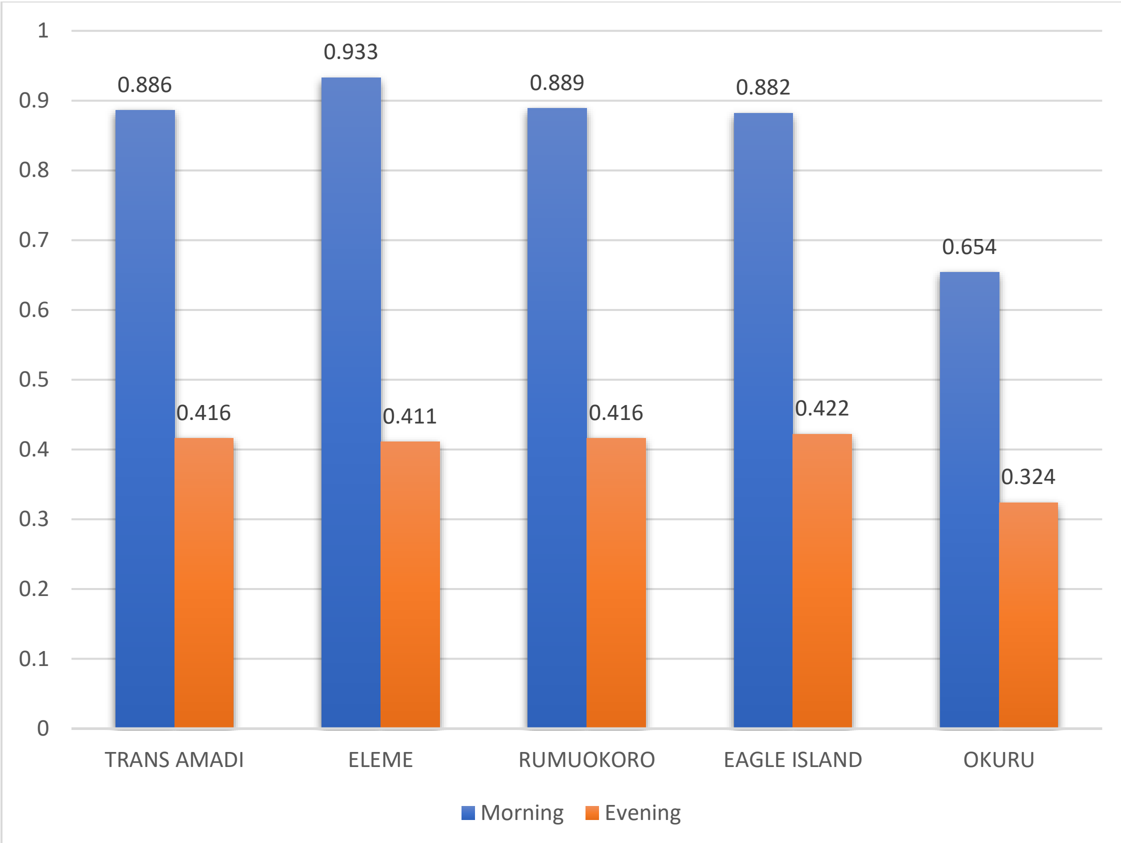

Fig.7: Mean concentrations of NH_3 (μg/m^3) in the various slaughterhouses in the morning and evening.