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Assessing the Implications of Burning Tyres for Cattle Skin Processing in Slaughterhouses: Challenges and Solutions

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Abstract
The study aimed to assess the implications of burning tyres for cattle skin processing in slaughterhouses, focusing on challenges and solutions. Methodologically, a comprehensive investigation was conducted in five slaughterhouse locations in Port Harcourt, Nigeria, utilizing a completely randomized block design for data collection. Air quality tests were performed to measure concentrations of various pollutants, including sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), volatile organic compounds (VOCs), methane (CH_4), hydrogen sulfide (H_2S), ammonia (NH_3), and suspended particulate matters (SPM2.5 and SPM10). The mean concentrations of these pollutants were analyzed using ANOVA and Duncan Multiple Range Test. Results indicated significant variations in pollutant concentrations across slaughterhouse locations and periods. For instance, Rumuokoro consistently exhibited higher levels of pollutants compared to other locations. Major findings included mean morning concentrations of SO2 (0.471 µg/m3), NO2 (0.987 µg/m3), CO (0.789 µg/m3), VOCs (625.867 µg/m3), CH4 (0.412 µg/m3), H2S (0.726 µg/m3), NH3 (0.889 µg/m3), SPM2.5 (64.714 µg/m3), and SPM10 (62.367 µg/m3) at Rumuokoro. In conclusion, exposure to emissions from burning tyres poses significant risks to public health and the environment, particularly in urban areas. However, solutions are available to mitigate these challenges. Proposed solutions include implementing alternative waste disposal methods, strengthening regulatory enforcement, launching public awareness campaigns, investing in technology for waste management, fostering collaboration and partnerships, providing training and capacity building, and supporting research and innovation initiatives.

Keywords: Air Quality, Slaughterhouses, Air Pollutants, Sulfur Dioxide, Nitrogen Dioxide Monoxide

Introduction

Managing pollution from end-of-life tyres (ELTs) is a pressing issue, particularly in developing nations like Nigeria. While developed countries find productive uses for over 300 million scrap tyres annually, such as energy generation and civil engineering, lack of technology and cost constraints hinder similar practices in developing nations (EPA, 1997; WBCSD, 2008). In Nigeria, tyres are often burnt in waste bins or used in bonfires during civil unrest or festive occasions due to the scarcity of alternatives. When tyres burn, they release various harmful compounds and particles into the environment, including carbon monoxide, sulphur oxides, nitrogen oxides, volatile organic compounds, and hazardous air pollutants like dioxins and furans (EPA, 1997). Metals like arsenic and chromium are also emitted, predominantly as particulate matter (Okonkwo et al., 2014). Research indicates that emissions from burning tyres are more toxic than those from typical combustors (EPA, 1997; Fierro, 2000). The World Health Organization has highlighted the health risks associated with exposure to airborne particulate matter, linking it to respiratory issues, cardiovascular diseases, and certain cancers (WHO, 2000; Samet et al., 2006). Despite these risks, monitoring and data management for ELT emissions are often inadequate in many regions, including sub-Saharan Africa.

In Nigeria, burning tyres are commonly used in abattoirs for cattle skin processing, posing health risks to workers and the public. Apart from the immediate health hazards, the environmental impact of tyre burning is significant, contributing to air and soil pollution. However, this practice continues due to limited awareness of its consequences and the absence of viable alternatives. Efforts to address this issue must consider both environmental and health concerns, as well as socio-economic factors. Proposed solutions include promoting alternative waste disposal methods, such as recycling and composting, to reduce reliance on tyre burning (EPA, 1997; Fierro, 2000). Strengthening regulatory enforcement to prohibit tyre burning in slaughterhouses is essential, accompanied by strict penalties for non-compliance. Public awareness campaigns can educate stakeholders about the environmental and health hazards of tyre burning, encouraging behavioural change. Additionally, investing in technology for waste management and disposal, such as advanced incineration technologies and pollution control devices, can help minimize emissions and pollutants released during the burning process. Collaboration between government agencies, environmental organizations, and stakeholders in the slaughterhouse industry is crucial for the effective implementation of these solutions. Capacity-building programs for slaughterhouse workers on proper waste handling and disposal techniques can promote safer practices and reduce environmental impacts. Research and innovation initiatives aimed at finding alternative uses for waste tyres can offer sustainable solutions and promote circular economy principles. Addressing the challenges associated with burning tyres in slaughterhouses requires a multi-faceted approach, considering environmental, health, and socio-economic factors. By implementing these solutions, we can mitigate the environmental and health hazards associated with this practice, paving the way for a cleaner and healthier future for all.

Materials and Methods

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, Eleme, Rumuokoro, Eagle-Island, and Okuru. 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.

Gas parameters including SO_2, NO_2, CO, VOC, CH_4, H_2S were measured at slaughterhouses. Hand-held equipment collected data from Trans-Amadi, Eleme, Rumuokoro, Eagle-Island, and Okuru sites over twelve months. Handheld air quality monitoring equipment was used to determine suspended particulate matters ($SPM_{2.5}$ and SPM_{10}) at Trans-Amadi, Eleme, Rumuokoro, Eagle-Island, and Okuru slaughterhouses over twelve months. Data collection occurred in morning and evening periods from February 2020 to January 2021. The AeroQual Air Analyzer, Series 500, measured air parameters and SPM concentration. Statistical analysis was performed using SPSS, calculating mean concentrations and standard deviations. Results underwent ANOVA and Duncan Multiple Range Test comparisons with established particulate standards by Rivers State Government, NAAQS, WHO, and FMENV.

This sampling was done with a hand-held air quality monitor (dry cell battery) to determine the concentration of air pollutants and suspended particulates in the slaughterhouses. AeroQual Air Analyzer, Series500 was used in situ to establish the concentration of the different air parameters in the slaughterhouses. GPS handheld device (Global Positioning System (GPS) model DT 49042-33) was used to take all geographical locations of the slaughter points (Trans-Amadi, Eleme, Rumuokoro, Eagle- Island and Okuru) slaughterhouses. The locations were given in coordinates, latitude and longitude. Analysis of air pollutants, particulates, and meteorological data utilized SPSS (version 27.0) for Windows. Mean concentrations and deviations were computed. ANOVA and Duncan Multiple Range Test were applied. Results were compared with air quality standards set by Rivers State Government, NAAQS, WHO, and FMEN.

Results

Air pollutant gas analysis at slaughterhouses showed higher levels in the morning compared to the evening. Mean ± standard deviation concentrations of SO_2, NO_2, CO, VOC, CH_4, H_2S, and NH_3 were presented in the tables below for Trans-Amadi, Eleme, Rumuokoro, Eagle-Island, and Okuru slaughterhouses.

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

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE 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 ($\mu g/m^3$) in the various slaughterhouses in the morning and evening.

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE 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

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

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE 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 ($\mu g/m^3$) in the various slaughterhouses in the morning and evening

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE 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	17.425	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 ($\mu g/m^3$) in the various slaughterhouses in the morning and evening.

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE 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 ($\mu g/m^3$) in the various slaughterhouses in the morning and evening

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE 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.8: Mean ± SD concentrations of NH_2 ($\mu g/m^3$) in the various slaughterhouses in the morning and evening.

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE 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

Table.9: Mean ± SD concentrations of H_2S ($\mu g/m^3$) in the various slaughterhouses in the morning and evening

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE 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

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Air Quality for Suspended Particulate Analysis

Tables 10 & 11 show higher morning concentrations of SPM2.5 and SPM10 in slaughterhouses, exceeding WHO standards.

Table.10: Mean ± SD concentrations of $SPM_{2.5}$ ($\mu g/m^3$) in the various slaughterhouses in the morning and evening.

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE Evening
TRANS AMADI	69.902	39.204	9.885	9.815	14.14	14.14	32.573	12.171
ELEME	65.074	35.011	8.292	8.212	12.74	12.74	22.917	12.213
RUMUOKORO	64.714	34.715	8.925	8.305	13.79	13.19	26.551	16.252
EAGLE ISLAND	68.111	38.106	8.311	8.301	12.20	12.20	23.024	13.010
OKURU	51.302	21.311	6.419	6.409	8.32	2.32	18.452	12.414

Table.11: Mean ± SD concentrations of SPM_{10} ($\mu g/m^3$) in the various slaughterhouses in the morning and evening.

LOCATION (STUDY AREA)	Mean Morning	Mean Evening	SD Morning	SD Evening	COV Morning	COV Evening	SE Morning	SE Evening
TRANS AMADI	60.118	30.104	7.675	4.615	13.22	11.24	30.341	20.120
ELEME	57.202	37.105	6.908	4.308	10.09	10.03	20.212	10.114
RUMUOKORO	62.367	32.313	8.112	3.102	10.87	10.11	24.754	14.156
EAGLE ISLAND	64.865	34.812	7.541	4.511	11.18	11.09	22.033	12.031
OKURU	45.233	25.211	5.455	3.415	8.11	4.15	19.311	13.315

Discussion

The study presents data indicating variations in sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) concentrations across slaughterhouse locations and periods. Rumuokoro consistently exhibits higher levels of both pollutants compared to other locations, indicating potential sources of industrial emissions or urban activities. For instance, the mean morning concentration of SO_2 in Rumuokoro is 0.471 $\mu g/m^3$, decreasing to 0.271 $\mu g/m^3$ in the evening. Similarly, the mean morning concentration of NO_2 in Rumuokoro is 0.987 µg/m3, decreasing to 0.513 $\mu g/m^3$ in the evening.

While these findings do not directly correspond with WHO standards, it's essential to recognize that exposure to high levels of SO_2 and NO_2 can lead to respiratory issues and exacerbate existing respiratory conditions. Therefore, efforts to monitor and mitigate emissions at slaughterhouses are crucial for protecting public health, particularly in areas where concentrations exceed recommended guidelines. The higher pollutant concentrations in urban areas like Rumuokoro could be attributed to industrial activities or vehicular emissions, while lower concentrations in rural areas like Okuru may be due to less anthropogenic activity and dispersion of pollutants.
Although strategies to reduce emissions and improve air quality are necessary, it's imperative to consider the implications beyond immediate health risks. Elevated pollutant levels contribute to long-term environmental degradation, emphasizing the need for comprehensive measures to address both immediate and long-term impacts.
Table 3 reveals variations in carbon monoxide (CO) concentrations across slaughterhouse locations and periods, with Rumuokoro consistently displaying higher levels. For instance, the mean morning concentration of CO in Rumuokoro is 0.789 $\mu g/m^3$, decreasing to $\mu g/m^3$ in the evening.

While these findings do not directly align with WHO standards, it's crucial to acknowledge that exposure to high levels of CO can lead to adverse health effects, including headaches and cardiovascular issues. Therefore, efforts to monitor and mitigate CO emissions at slaughterhouses are necessary to protect public health, particularly where concentrations exceed recommended guidelines. Higher CO levels near urban centres like Rumuokoro may result from traffic congestion and industrial combustion. Similarly, Table 4 illustrates variations in volatile organic compounds (VOCs) concentrations across slaughterhouse locations, with Rumuokoro consistently exhibiting higher levels. For instance, the mean morning concentration of VOCs in Rumuokoro is 625.867 $\mu g/m^3$, decreasing to 325.817 $\mu g/m^3$ in the evening. Although these findings do not directly reference WHO standards, exposure to certain VOCs can have detrimental health effects, including respiratory issues and neurological disorders. Therefore, efforts to monitor and mitigate VOC emissions at slaughterhouses are crucial for protecting public health, particularly where concentrations exceed recommended limits.

Higher VOC concentrations near urban centres like Rumuokoro may result from industrial processes and vehicle emissions, while lower concentrations in rural areas like Okuru could be due to less industrial activity. Effective measures to control emissions are necessary to safeguard public health and mitigate environmental impacts. Methane (CH_4) concentrations vary across slaughterhouse locations and periods, with Rumuokoro consistently displaying higher levels. For instance, at Rumuokoro, the mean morning concentration of CH_4 is 0.412 $\mu g/m^3$, decreasing to 0.112 $\mu g/m^3$ in the evening.

Although these findings do not directly correspond with WHO standards, methane, as a greenhouse gas, contributes to climate change and poses risks to public health. Therefore, efforts to monitor and mitigate CH_4 emissions at slaughterhouses are necessary to reduce environmental impacts and protect public health. Higher CH_4 concentrations near urban centres like Rumuokoro may result from waste decomposition and industrial activities.

Hydrogen sulfide (H_2S) concentrations also vary across slaughterhouse locations, with Rumuokoro consistently displaying higher levels. For example, at Rumuokoro, the mean morning concentration of H_2S is 0.726 µg/m^3, decreasing to 0.316 µg/m^3 in the evening. Exposure to high levels of H_2S can lead to respiratory issues and neurological effects. Therefore, efforts to monitor and mitigate H_2S emissions at slaughterhouses are crucial for protecting public health, especially in areas where concentrations exceed recommended guidelines. Higher H_2S concentrations near urban centres like Rumuokoro may result from industrial processes and waste decomposition. Ammonia (NH_3) concentrations also vary across slaughterhouse locations, with Rumuokoro consistently displaying higher levels. For instance, at Rumuokoro, the mean morning concentration of NH_3 is 0.889 µg/m^3, decreasing to 0.416 µg/m^3 in the evening. Exposure to high levels of NH_3 can lead to respiratory issues and contribute to air pollution. Therefore, efforts to monitor and mitigate NH_3 emissions at slaughterhouses are necessary for protecting public health, especially in areas where concentrations exceed recommended guidelines. Higher NH_3 concentrations near urban centres like Rumuokoro may result from waste decomposition and agricultural activities. Effective measures to control emissions are necessary to safeguard public health and mitigate environmental impacts. $SO_{2.}$.

On suspended particulate matter ($SPM_{2.5}$) concentrations across slaughterhouse locations, Rumuokoro consistently exhibits higher concentrations, with morning levels at 64.714 µg/m^3 and evening levels at 34.715 µg/m^3. This suggests emissions from industrial activities or vehicular traffic. Although not meeting WHO standards, high $SPM_{2.5}$ levels pose risks to respiratory and cardiovascular health. Efforts to monitor and mitigate emissions are crucial, particularly where concentrations exceed guidelines. Higher levels near urban centres like Rumuokoro may result from industrial activities, vehicular emissions, or other anthropogenic sources. On coarse particulate matter (SPM_{10}) concentrations, Rumuokoro again showing higher levels. Morning concentrations are at 62.367 µg/m^3 and evening levels at 32.313 µg/m^3. While not meeting WHO standards, elevated SPM_{10} levels pose risks to respiratory health and exacerbate existing conditions. Mitigation efforts are necessary, especially where concentrations exceed guidelines. Higher levels near urban centres may result from industrial activities or vehicular emissions, while lower levels in rural areas could be due to less industrialization. Effective measures to control emissions are necessary to safeguard public health and mitigate environmental impacts.

Conclusion

The findings of this study underscore the alarming environmental and health implications associated with the burning of tyres in slaughterhouses, particularly in Port Harcourt, Nigeria. The assessment of air quality revealed elevated levels of various air pollutants, including sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), volatile organic compounds (VOCs), methane (CH_4), hydrogen sulfide (H_2S), and ammonia (NH_3), exceeding WHO standards at all slaughterhouse locations. The presence of these pollutants not only poses immediate health risks to workers and nearby communities but also contributes to long-term environmental degradation. High concentrations of air pollutants can lead to respiratory issues, cardiovascular diseases, and other adverse health outcomes, particularly among vulnerable populations such as children, the elderly, and individuals with pre-existing health conditions. Furthermore, the excessive levels of suspended particulate matter ($SPM_{2.5}$ and SPM_{10}) observed in the study area indicate significant risks to both human health and the environment. SPM, composed of dust particles containing organic compounds and minerals, can cause respiratory problems, cardiovascular diseases, and even premature mortality upon inhalation. Additionally, the deposition of SPM on surfaces contributes to aesthetic degradation and environmental pollution. The implications of these findings extend beyond the immediate vicinity of slaughterhouses, affecting broader ecosystems and communities. The indiscriminate burning of tyres not only releases harmful pollutants into the air but also contributes to soil and water contamination, further exacerbating environmental degradation.

Suggestions

Assessing the implications of burning tyres for cattle skin processing in slaughterhouses poses significant challenges, but solutions exist to mitigate these issues:

1. **Alternative Waste Disposal Methods:** Encouraging environmentally friendly waste disposals techniques such as recycling, composting, or waste-to-energy technologies can reduce reliance on tire burning.
2. **Regulatory Enforcement:** Strengthening regulations to prohibit tyre burning in slaughterhouses, with strict penalties for non-compliance, is crucial.

3. **Public Awareness Campaigns:** Educating stakeholders about the hazards of tyre burning through public awareness campaigns can promote safer waste disposal practices.
4. **Investment in Technology:** Implementing advanced incineration technologies or pollution control devices can minimize emissions during the burning process.
5. **Collaboration and Partnerships:** Collaboration among government agencies, environmental organizations, and stakeholders can lead to sustainable waste management practices.
6. **Training and Capacity Building:** Providing training programs for slaughterhouse workers on proper waste handling can reduce environmental impacts.
7. **Research and Innovation:** Supporting research for alternative uses of waste tyres can minimize the need for burning and contribute to environmental conservation.

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