



## ASSESSMENT OF THE ECONOMIC AND ENVIRONMENTAL EFFECTS OF ODOR EMISSION FROM MECHANICALLY VENTILATED LIVESTOCK BUILDING IN IBADAN OYO STATE NIGERIA

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### ABSTRACT

Odors from livestock facilities and waste products still remain a serious environmental problem confronting both the producers and the general public in Nigeria. This study was conducted with the aim of analyzing the perceptions of Ibadan dwellers on livestock odor and the economic and environmental consequences of this odor in Oyo state. This was achieved through purposive sampling of two mechanically ventilated poultry, pig and goat/sheep farms each and interviewing 10 people living very close to each farm. Responses to a well designed questionnaire were analyzed with the Likert Five Points Rank Ordered Scale. The amount of odor emitted vary according to animal species, housing types, manure storage, handling methods, the size of the odor sources and the use of odor control technologies. The impacts of these livestock odors on the surrounding neighborhood or community also depend on the amount of odor, distance of the livestock building or facility to residential area and the weather conditions. The closer the facility, the greater the odor impact. In Ibadan, Livestock odor is strongly perceived to be irritating, major cause of rift between the keepers and their neighbors as well as a major cause of some diseases. Elimination of livestock odors entirely in Ibadan still remains a very difficult task, but odor complaints can be minimize through general cleanliness of animals and buildings, frequent manure removal and proper site selection which must be of a distance from neighbors. In addition, there must be open communication and good relationship between livestock producers and the neighbors to avoid neighbor's complaints and promote acceptance of their livestock production.

**KEYWORDS:** Livestock, Odor emission, neighbor, perception and complaint

### INTRODUCTION

Environmental pollution and Odor complaints related to animal production have increased dramatically during the past decade (Ernest and Ronald, 2004). Pollution from animal manure is a global concern and is much more acute and serious in countries with high concentrations of animals on a limited land base for manure disposal (Roderick, Stroot and Varel, 1998). Livestock odor is caused when organic matter such as manure decomposes and releases gases containing chemicals such as ammonia and hydrogen sulfide, which smells like rotten eggs (Minnesota Pollution Control Agency (MPCA) (2006). Over 168 compounds such as hydrogen sulfide and ammonia have been identified to contribute to odor from livestock manure (Livestock Odor Task Force report, 2007). These odors potentially interfere with quality and enjoyment of life (Mauderly, 2002 and Albert, 2002). The question therefore is "why is livestock odor an issue in Ibadan and Nigeria now compared with 20 to 30 years ago?"

Recently in Nigeria, complaints about livestock odors have increased both in the urban and rural areas as poultry and hog operations have grown in size. Odors and toxic gases are emitted from any livestock production enterprise. The emissions sources are distributed between the livestock buildings and manure storage units (Rom,

1993). Odor complaints are more common when the humidity is high and the air is still or when the prevailing breezes carry odors toward populated areas (Pfof, Fulhage and Hoehne, 1999). When the air is still, odors flow down slopes much as water does (Fulhage, McNabb and Rea, 1993). Surface application of relatively fresh solid manure, or manure slurry, without immediate incorporation also causes high odor levels (Pfof, Fulhage and Hoehne, 1999).

Livestock operations result in conversion of feeds into valuable products such as meat, milk, eggs, and wool (Mackie, Stroot and Varel, 1998). However, odor from livestock still remains a major obstacle to future development of the animal industry if its impact on the environment is not properly controlled. The public's increasing intolerance of livestock odors, coupled with the economic importance of animal agriculture and the society at large has therefore called for a study like this in order to look for a way of finding solutions. The main objective of the study is to assess the economic and environmental effects of odor emission from mechanically ventilated livestock buildings in Ibadan Oyo state, Nigeria. Specifically, the study aims at analyzing the public perceptions on livestock and odor problem in Ibadan Metropolis, to investigate the environmental and economic effects of livestock odor in Ibadan, to investigate the strategies livestock owners have adopted in Ibadan at the reduction of their

livestock odor and finally to make possible suggestions on a sustainable livestock development so as to make livestock environmentally friendly in the study area

### **THEORETICAL UNDERPINNING OF LIVESTOCK ODOR**

Animal Odor, like noise, is a nuisance or disturbance but unfortunately there is no universally accepted definition of an objectionable odor (Mackie, Stroot and Varel, 1998). Feed and body odors are not regarded as offensive, but those generated from livestock manure and its decomposition during collection, handling, storage, and spreading are considered offensive (Mackie, Stroot and Varel, 1998).

The term "odor" refers to the perception experience when one or more chemicals come in contact with the receptors on the olfactory nerves and "stimulate" the olfactory nerve (McGinley, Thomas, Richard and Pope, 2000). Livestock excreta consists of undigested organic residues, including proteins, carbohydrates, and fats. Under aerobic conditions the carbon, nitrogen, and sulfur compounds are degraded into carbon dioxide, nitrate, sulfate, and water. Under anaerobic conditions, if the organic matter is completely degraded, methane, carbon dioxide, hydrogen sulfide, ammonia, and water are by-products. This results in the emissions of ammonia and associated nitrogen compounds such as volatile fatty acids (VFA), sulfur compounds, various alcohols, and aromatic (indole, skatole, and cresol) compounds (Watts, Jones, Tucker and Smith, 1994) which are offensive to the general public, and are considered nuisance odor compounds.

Livestock manure is subject to anaerobic degradation under a variety of moisture and temperature conditions, resulting in the generation of odorous volatile compounds (Mackie, Stroot and Varel 1998). Odors emanating from swine operations are recognized and regulated as a public nuisance in most countries such as the United States (Miner, 1997). These odors are a complex array of volatile organic compounds resulting from the fermentative degradation of carbohydrates, fats, and proteins by a variety of indigenous bacterial species present in the large intestine and manure of swine (Zhu and Jacobson, 1999). Therefore diet compositions may affect odor emission from swine manure (e.g., high-protein diets increase odorants) (Hobbs, Pain, Kay and Lee, 1996).

Accurately quantifying an odor emission is difficult because individuals experiencing the odor may perceive it differently depending on their previous experiences with the particular odor, as well as factors such as their mood, health, or age. This may explain why people who work with livestock on a daily basis cannot fully understand the complaints from neighbors who have less exposure to these odors (Shiffman, 1998). A conceptual model for what leads to an odor nuisance is the "people / Citizen Complaint Pyramid" (See Figure 1) which starts and builds with "Odor Character" or "quality" of the odor or the "offensiveness" of the odor (McGinley, Thomas, Mahin and Pope, 2000). This is the actual description of what the odor "smells like" (McGinley and McGinley,

2000). Followed by this is "Odor Intensity", "Episode Duration", and "Episode Frequency" respectively. The cumulative effect of these four building blocks creates the nuisance experience that may yield a citizen complaint (McGinley and McGinley, 2000).

"Odor Intensity," the second building block of the complaint pyramid refers to the overall strength of the perceived odor. The more intense the odor, the more likely an individual citizen will be annoyed. Even pleasant odors such as perfumes can be very annoying at high intensities and, conversely, offensive odors such as "fishy" can be very annoying at low intensities (McGinley and McGinley, 2000). Duration, the third building block of the complaint pyramid, is the elapsed time of each separate odor episode and may be an objective time measurement depending upon the situation. An odor episode is a period of time in which citizens are exposed to the odor. Longer duration odor episodes can cause citizens a lack of quality of life and force them to make changes in activities or future plans for their property or the community. Odor episodes of short duration may be annoying but expire before the citizen adjusts activities or plans (McGinley and McGinley, 2000). The final building block of the complaint pyramid is the odor episode's frequency, which refers to how often the citizen experiences odor episodes of any type. The more frequent that odor episodes intrude into a citizen's life, the more annoying each odor episode experience becomes ((McGinley and McGinley, 2000).

### **METHODOLOGY**

Ibadan is the capital city of Oyo State, Nigeria, located on longitude 3<sup>o</sup>54'E and latitude 7<sup>o</sup>23'N. Apart from Lagos, the commercial capital of Nigeria, Ibadan is now the largest and most cosmopolitan city in southwestern Nigeria (Gbadegesin, 2001). The residential land use in Ibadan has been stratified into three zones; the high density/traditional residential zone; the medium density zone and the low-density zone (Gbadegesin 2001). The high-density zone of the city is the oldest part of the metropolis accounting for about 18% of the total land area. The zone is occupied mainly by the indigenes of the town. In this zone, goats, sheep and dogs roam freely without anyone claiming ownership. The medium-density occupies more than a quarter of the land area of the city. In this zone, indigenes and immigrants to the metropolis live together. Lower; middle and upper classes inhabit the zone. Consequently, livestock holdings vary between houses in the zone. The low-density zone occupies about 20% of the total land area of the city. Most of the residents of this zone are top civil servants and business executives, as well as university lecturers and senior army officers. Although property watchdogs comprise the majority of "livestock", poverty has made the backyards and garages of the buildings attractive places for livestock rearing.

Chickens are the most numerous types of livestock kept by residents of Ibadan both in actual number and the number of households. In the medium and low density zones, chickens are raised in the backyard of buildings. The predominance of chicken over other livestock is probably due to the fact that poultry and egg production is the most profitable and attractive form of livestock rearing that also gives quick returns on

investments. Next to chicken in abundance are small ruminants such as goats (table 1). Goats (principally West African dwarf in addition to a few Sokoto red) are kept as backyard or free roaming animals browsing on the garbage in back streets in all the zones. Other animals of importance in the city are sheep, pigs, ducks, rabbits and snails. There is a spatial differentiation in the number of and households keeping pigs in the city. As shown in Table 1, residents of the medium and low density areas own most of the pigs, and allow the animals to roam freely and feed on households refuse. The number of pigs in the high-density zone is limited because many of the residents inhabiting this zone are of the Islamic faith. In the early 1990s large livestock, especially cattle, were rarely found reared in the city. In recent years, cattle ownership has become more popular due to the potential profits realized from the business.

#### **Sampling Procedure and Methods of Analysis**

A multi-stage sampling procedure was employed in the study. In the first stage, mechanically ventilated poultry, sheep/goat and pig farms in Ibadan were identified. After identification, the second stage involved the purposeful sampling of two poultry farms, two pig farms as well as two goat/sheep farms. In the third stage, 10 people living very close to each of the selected farms were randomly selected to avoid being biased. Twenty neighbors were interviewed relating to poultry farms, 20 for goat/sheep farms and 20 for pig farms. The respective farms owners were also interviewed on the strategies they had adopted in coping with their livestock odors and their neighbors. Data were collected from the respondents through their responses to some statements in respect to livestock as it applies to them. The collected data were analyzed with simple descriptive statistics such as the Likert 5 points rating scale. In the scale, statement like “Strongly Agreed” (SA) has 5 points, “Agreed” (A) has 4 points, “Undecided” (U) has 3 points, “Disagreed” (D) has 2 point and “Strongly Disagreed” has 1 point. Mean Score (MS) is calculated by summation of the product of rating point and observation divided by the total number of sampled respondent. Mathematically:  $MS = (\sum (RP \times O) / \sum f)$

## **RESULTS AND DISCUSSION**

### **Neighbors’ Perceptions on the Environmental Impacts of Livestock in Ibadan, Nigeria**

Livestock odors remain one of the top air pollution complaints to regulators and government bodies in Nigeria. Livestock production facilities, regardless of the level of waste disposal, feed management, or ventilation system employed produce more than 160 odorous compounds (Funk, 2003). This odor can impact the health, economic status, and personal security of persons who live or work near production sites as well as environmental quality (Hoag and Roka, 1995; Roka and Hoag, 1996; Letson and Gollehon, 1996; Hurley, Kliehenstein and Orazem, 1996). The study revealed that people in Ibadan don’t like smelling something they have no control over, especially when it comes to livestock manure in line with

Schmidt (1996) observations. Odor complaints have been found to be one of the most negative impacts of livestock production as viewed by people living around most livestock houses or livestock market places in Ibadan Oyo state. The level of livestock odor complaints continues to increase in the city as a result of three major factors: an increase in the number of people raising animals in their backyards to supplement their income, an increase in density of livestock (more animals per site) as well as an increase in numbers of people (both farm and non-farm) living near livestock farms. With trends moving toward larger livestock especially poultry farms, controlling odors, gases and dust has become a greater concern for producers and their neighbors. Unfortunately neither Nigeria government nor Oyo State where Ibadan is located has any regulation for controlling livestock odors in the environment.

The results of analysis of respondents to certain statements using Likert rating scale shows that neighbors of livestock farms perceived livestock odors differently. As shown in Table 2, people living very close to poultry farm strongly agreed with the statements that inadequate disposal of poultry waste is irritating, and that livestock odors are capable of causing disease. These perceptions have also caused rifts between livestock keepers and neighbors. Respondents in this category however disagreed or remained undecided with the statements that ‘poultry’ and not poultry waste is irritating, manure from poultry leads to water pollution, poultry feed and the dirty poultry environment prevents them from consuming the animal. A majority of respondents also disagreed with the statement that stray livestock are capable of causing traffic chaos.

On the other hand, analysis of the perceptions of the people living very close to pig farms shows a strong agreement with the statement that the non-consumption and the dislike of pigs by some people, apart from religion reasons, are due to the dirty behavior of the animal and the range of materials consumed by this animals such as dead bodies, feces etc. There is also a strong agreement with the statements that manure from pigs is capable of polluting nearby water. Inadequate management of pig houses, odor from the pigs themselves and odors from the waste in Ibadan metropolis are very irritating, leading to high level of public nuisance unlike in poultry. This finding is in conformity with Schiffman, Miller, Suggs and Graham, (1995) who opine that neighbors of swine farms suffered more mood disturbances and negative emotions than other livestock species. It was strongly agreed that uncontrolled grazing of pigs in open places leads to erosion and destruction of farm produce, odors from pigs and their waste is capable of causing various forms of diseases as well as a major cause of rift between neighbors and pig keepers. Stray pigs are also capable of causing traffic chaos.

Neighbors of goat/sheep farms strongly agreed with the statement that, inadequate management of goat farms, which generate obnoxious odors, beside the odor generated from the animal itself, causes a public nuisance and discourages some people from neither having anything to do with goats nor consuming them.

### **Economic Effects of Livestock Odor**

Very little information is available on the economic effects of odor on human health from the respondents in Ibadan. Respondents believe that odors from livestock make them sick when inhaled. Symptoms reported include: headaches, nausea, reflex nausea, gastrointestinal distress, fatigue, eye irritation, throat irritation, shortness of breath, runny nose, sleep disturbance, inability to concentrate, and classical stress response.

The study also revealed that one of the major costs incurred by livestock producers is the cost of removal of livestock waste products and the general cleaning of the livestock building. Due to the combination of urine with other by-products, the cost was found to be higher by those keeping swine, goat and sheep compared with those of poultry. An average of ₦200 (equivalent to U.S \$1.67) is normally spent on labor to clean-up single swine or goat facility daily. In addition, farmers also found it difficult to obtain modern technology for manure treatment.

### **Strategies at Reducing Livestock Odor**

Although ventilation of livestock and poultry buildings improves animal productivity and well-being, the emission of odorants in the vapor or particulate from the buildings contributes significantly to odor problems (Bottcher, 2001). While some of the studies on livestock odors have looked at altering livestock feeds so as to make animal more efficient in utilizing the basic diet ingredients, especially protein, others have taken an engineering approach, using biofilters and air scrubbers to remove ammonia, other gases, and odorous compounds from the building's air. Additional research has been done in developing alternative manure collection systems which reduce the amount of manure and urine remaining on solid floor surfaces. By removing manure quickly from solid surfaces, the conversion of urea into ammonia is lowered significantly (Jacobson, 1995). The result from this study shows the most common method adopted for mechanically ventilated livestock farms as the removal of their livestock waste immediately. Unfortunately, over 90% of the sampled farmers do not have a regular schedule of carrying out this operation in Ibadan. The findings show that some livestock keepers delay the removal of their animal waste even after receiving complaint of the odor from neighbors owing to what they called "busy time schedule" for other activities. Unfortunately only a few producers (40%) disposed such waste far from where their livestock are kept. The remaining 60% merely selected the waste site to prevent disease outbreak in their livestock houses with only minimal concern on their neighbors.

### **CONCLUSIONS AND RECOMMENDATIONS**

Although livestock are valuable commodity, the odors arising from livestock production facilities have a deleterious impact on the quality of life. The volume of manure generated from livestock today may be a major obstacle to future development (Asia-Pacific Economic Cooperation, 2000). Livestock odors vary greatly, and the offensiveness of each odor is dependent upon the person

smelling the odor (Zhang and Harmon, 2001). Some odors are generated by the animals and the dander from their bodies; some odors are from the animals' feed; and some odors, usually the strongest, are from the livestock manure and decomposition of that manure. It is observed that poor odor prevention and control from animal wastes is related to a lack of knowledge of the fundamental nature of odor and its production by domestic animals in line with Mackie, Stroot and Varel (1998).

The diets of animals have a large effect on the nature of the manure excreted and the level of odor emitted. Reducing dust in an animal confinement building can also substantially cut odor levels (Zhang, 2003). Even if livestock odor cannot be completely eliminated, the problems can be minimized through proper management and good neighbor relations. Many management practices can be implemented to reduce odor problems. The most important of these being general cleanliness of animals and buildings. Frequent manure removal, site selection and control of large land area surrounding large livestock operations also will help at odor reduction (Rappert and Muller, 2005). Careful selection of when to apply manure to agricultural land and use of practices such as injection or incorporation of manure will also reduce odor complaints. Open communication and good relationships with neighbors will help decrease complaints and promote acceptance of livestock production. Another critical way to control odor emissions is by regulating the volatilization rate. Six factors which influence the volatilization rate: source concentration; surface area; net radiation; air temperature; wind velocity; and relative humidity (Varel, 2001). Covering waste storage basins reduce volatilization rates by decreasing solar radiation and direct wind velocity stripping of the volatile organic compounds. This is in line with Zahn's (1997) recommendations. Livestock keepers should eliminate untimely removal of waste products and poor technology that have a direct bearing on odor emissions by adopting manure storage technologies that reduce or prevent emission of volatile odorous components.

The amount of odors emitted from a livestock operation depends on the amount and type of microbial degradation of manure (Nicolai and Pohl, 2005). Odor control technologies include those that are intended to (1) prevent odors from being generated, (2) capture and destroy odors before they are released to the atmosphere, or (3) disperse or disguise odors so they do not create a nuisance (Schmidt and Jacobson, 1995). Technologies that prevent the initial generation of odors are often categorized as manure treatment. Anaerobic digestion, aeration or oxidation, feed additives, manure additives, and Potency of Hydrogen (PH) control fall within this category. Technologies that capture and treat odors include manure storage covers, organic mats, and biofilters. Technologies that disperse or mask odors include stacks, wind breaks, site selection, perfumes, or masking agents (Nicolai and Pohl, 2005)

An odor rating system needs to be developed by the government agency responsible for environmental health in Ibadan Oyo State and Nigeria, as a means to predict and compare odor emissions from farms. This action coupled with regulating agricultural zones, and establishment of emission

standards for livestock operations can also reduce impact on neighboring residential areas. Finally, there is the need to spray small amount of vegetable oil inside a confinement barn every day to reduce the amount of dust in the exhaust (Zhang, 1997).

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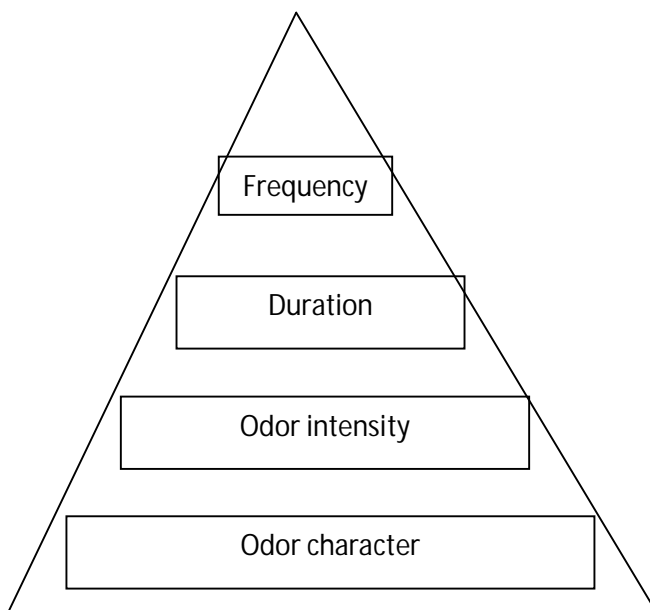
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**Figure 1:** Livestock Odor Complaint Pyramid



Source: Adapted from McGinley, et al (2000): Elements of Successful Odor/Odour Laws; Water Environment Federation Odors and VOC Emissions 2000 Specialty Conference, Cincinnati, OH. April, 2000

**Table 1:** Urban Livestock Population In Residential Zones Of Ibadan

Species	High Density	Medium Density	Low Density	Total	Density/km <sup>2</sup>
Donkeys	101	0	0	101	0.56
Goats	21184	16716	1931	39831	219.29
Sheep	822	1796	176	2794	15.40
Pigs	53	1077	225	1355	7.47
Dogs	1217	2367	1926	5519	30.38
Rabbits	1664	4419	2332	7915	43.64
Guinea-pigs	45	878	94	1017	5.61
Cats	314	959	178	1451	8.00
Chickens	61808	72863	13145	147816	814.91
Ducks	129	3552	1292	4973	27.42
Pigeons	3359	4120	402	7881	43.45
Guinea-fowl	0	18	450	468	2.58
Turkeys	0	7	293	300	1.65
Fish ponding	0	7	0	7	0.04
Fish welling	0	203	0	203	1.12
Snail farming	0	164	0	164	0.90

Source: Gbadegesin, 1991 Ibadan Urban Livestock Survey. Contribution to the report on Nigeria National Livestock and Resources Inventory Management Ltd. Kaduna, Nigeria (16pp.)

**Table-2**

Public Perceptions of Environmental Impacts of Livestock Odor And Some Other Characteristics In Ibadan Metropolis																					
Environmental Impacts of livestock	Neighbours perception located very close to poultry farms							Neighbours perception located very close to pig farms							Neighbours perception located very close to goat/sheep farms						
	SA	A	U	D	SD	MS	R	SA	A	U	D	SD	MS	R	SA	A	U	D	SD	MS	R
	5	4	3	2	1			5	4	3	2	1			5	4	3	2	1		
Livestock dirty behaviour make people to dislike them	1	1	1	1	3	2.15	D	20	0	0	0	0	5	SA	16	3	1	0	0	4.75	SA
What livestock eat make people to dislike them	0	0	1	5	14	1.35	SD	9	5	1	4	1	3.85	A	1	3	0	11	5	2.2	D
Odor from livestock leads to irritation	2	2	4	7	5	2.45	D	16	4	0	0	0	4.8	SA	18	2	0	0	0	4.6	SA
Livestock odor leads to public nuisance	0	1	6	8	5	2.15	D	15	4	1	0	0	4.7	SA	8	7	3	1	1	4.0	A
Livestock are vector of diseases	10	8	2	0	0	4.4	A	2	2	10	5	1	2.95	U	1	5	7	4	3	2.85	A
Livestock odor is capable of causing diseases	20	0	0	0	0	5	SA	20	0	0	0	0	5.0	SA	20	0	0	0	0	5.0	SA
Stray livestock sometime cause traffic chaos	4	5	4	4	3	3.15	A	16	4	0	0	0	4.8	SA	16	3	1	0	0	4.75	SA
Inadequate disposal of animal waste is irritating	20	0	0	0	0	5	SA	20	0	0	0	0	5	SA	20	0	0	0	0	5	SA
Noise from livestock causes public disturbance	6	7	3	2	2	3.65	A	18	2	0	0	0	4.9	SA	2	1	1	1	0	3.95	A
Uncontrolled livestock grazing leads to erosion and farm destruction	4	5	3	6	2	3.15	U	16	4	0	0	0	4.8	SA	15	5	0	0	0	4.75	SA
Livestock waste leads to water pollution	2	1	1	2	1	2.95	U	19	1	0	0	0	4.95	SA	1	1	1	3	5	2.5	U
Livestock odor causes rift between neighbours and livestock keepers	13	4	2	1	0	4.65	SA	17	1	2	0	0	4.75	SA	16	4	0	0	0	4.8	SA

Note: SA = Strongly Agreed, A = Agreed, U = Undecided, D = disagreed, SD= Strongly Disagreed, R = Remarks, Total number of respondents in each category (Σf) = 20, Mean score (MS) = summation (Σ) of rating point × number of observation / Σf  
 Source: Field survey, January 2007