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THE IMPACT OF MALODOUR EXPOSURE ON THE PSYCHOLOGICAL WELL-BEING OF A COMMUNITY IN TRINIDAD

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Abstract – Large-scale farm production processes produce variable amounts of effluent either in the form of chemical, biological or physical waste which may have a detrimental effect on both the environment and residential communities. In particular with intensive livestock farming, it has been shown that animals produce a large quantity of biological waste. Currently, with greater emphasis being placed on environmental and human health and safety, concern has now shifted to focus on the quality of life of individuals living around areas of intensive farming. This study examined the impact of malodours on the psychological well-being of residents living near an intensive pig farming operation in Trinidad, West Indies. Direct measures of gases were done over a 3 month period and community members (test community) were surveyed using a questionnaire to determine their perception of the severity of the malodors and its impact on their mood using sixty five (65) questions based on the established Profile of Mood State (POMS) measure. Repeat measures were done in a matched (control) community some 5000m away from the piggery. Data were assessed using paired t-tests and multiple regression analysis. Results showed: a significant difference in levels of ammonia and hydrogen sulphide between the test and the control areas; participants residing in the test area reported significantly ($p<0.05$) higher symptom rating scores for tension-anxiety, depression-dejection, anger-hostility, confusion-bewilderment, fatigue-inertia and total mood disturbance compared to participants residing in the control area; a positive association between psychological well-being scores and malodour scores ($\beta= 4.970$; $p=<0.001$). The findings suggest immediate intervention by the Environment Management Agency of Trinidad to have the piggery take measures to improve the situation so that the lives of community members and the surrounding environment are significantly improved.

INTRODUCTION

Large-scale farm manufacturing and production processes produce variable amounts of effluent either in the form of chemical, biological or physical waste which may have a detrimental effect on both the environment and residential communities. This type of production process, labelled as intensive farming, has been increasingly adopted by farmers in an effort to meet growing demand for food and food products. Such a farming system utilises a large input of financial resources and labour to help increase yield of a given commodity over a smaller farm area. At times, such intensive operations are carried out on small parcels of land that are usually in close proximity to local communities; mainly seen in low and middle income countries.

Although it has been shown that intensive crop farming has a negative effect on farmers, the residential community and the environment, livestock farming poses a larger detrimental effect (Heimlich, 2001). One of the major concerns which have arisen from both commodity –type farming operations has been the large production of waste and foul odours (Hobb, 1996; Miner, 1975). In particular with intensive livestock farming, it has been shown that these animals produce a large quantity of biological waste (Ilea, 2008). Cox (1975) noted that excessive odour has always accompanied animal rearing. This problem arises when a large

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quantity of livestock is being reared on a small areaof due to the lack of available land space. Neglect by farmers to dispose of such waste appropriately has led to an increase in environmental pollution and adverse health outcomes among farm workers and individuals residing near these operations (Hobb, 1996).

In commercial piggeries, pigs are usually reared in intensive commercial units; usually in confined building units and live their entire lives from birth to butchering in these units. This type of farming allows for large production rates of meat in a more controlled environment which prevents or reduces the risk of the animals contracting diseases in the animals. Intensive pig farming has grown rapidly because of the large global demand for pork in low-to middle income countries. Malodours are a usual consequence. Such malodours develop from improper waste storage and handling. Research has shown that the foulest odours emanate from a mixture of fresh and decaying faces, urine, spilled feed and anaerobic decomposition of faeces (Bundy 1992; Ritter, 1989).

Currently, with greater emphasis being placed on environmental and human health and safety, concern has now shifted to focus on the quality of life of individuals living around the area of intensive farming. Residents, unlike workers are exposed for a longer period of time on a daily basis. (Simonton and Spears, 2007) reported that while thelevels of effluents to which residents are exposed maybe lower than those of farm workers, it is the long term exposure periods that makes residents more susceptible to illnesses. Exposure to harmful breathable air over a long period of time in some cases can be just as catastrophic as short term exposures to ammonia (NH_3) and hydrogen sulphide (H_2S) (Griffin, 2006). An assessment of air quality (Schiffman *et al.*, 1998) showed that pig farms produced large quantities of hydrogen sulphide, ammonia, endotoxin and inhalable particulate matter. Reynolds *et al.*, (1997) stated that hydrogen sulphide (H_2S) and ammonia (NH_3) were the gases that were usually above environmental standards and that they pose the biggest threat to human health. The waste from pigs and cows contain higher concentrations of nitrogenous and carbon based waste such as ammonia, hydrogen sulphide, methane and particulate matter.

Animal rearing is a major source of aerial ammonia emissions into the surrounding atmosphere. Research has shown that elevated levels of the ammonia gas are largely seen in and around farming facilities (ApSimeon, 1987; Allen 1988; Koerkamp, 1998; Hobbs, 1996; Aneja, 2000; Battve, 1994; Kurvitis and Marata, 1998; Sommer and Hutchings, 1995). Ammonia can be formed in open feed yards, inside animal housing buildings, in manure storage ponds and storage facilities, during manure handling and its treatment and when manure is applied to soils as fertilizer.Because high concentrations of NH_3 may cause irritation of the respiratory lining, chemical burns to the respiratory tract, eyes and skin, severe cough and chronic lung ailment, some standards have been established. The Environmental Protection Agency (EPA) has recommended 1.4 ppm as a reference concentration for chronic long-term inhalation of ammonia .The Agency for Toxic Substances and Disease Registry (ATSDR) has also suggested a long-term (MRL) Maximum Residue Limit of 300ppb for communal exposures. These levels are much lower than Trinidad and Tobago's Occupational Health and Safety (OSH) standards which have ammonia (NH_3) at a Permissible Exposure Limit (PEL) of 50 ppm according to Occupational Safety and Health Authority (OSHA) and the Environmental Management Agency of Trinidad and Tobago (EMA) (Shah and Rivera, 2007). Noteworthy, is that the American Conference of Governmental Industrial Hygienist (ACGIH) and the (NIOSH) National Institute of Occupational Safety and Health has established a lower Time Weighed Average of 25 ppm.

Air quality research studies conducted by the University of Iowa Study Group reported that some of the ill effects of NH_3 were found to vary at different exposure concentrations (University of Iowa, 2002). These ill effects include symptoms such as coughing, wheezing, nasal complaints, eye irritation, throat irritation and skin complaints. Additionally, high exposure to high concentrations of NH_3 has also resulted in the development of severe pulmonary illnesses which may lead to prolonged morbidity and mortality of affected individuals.Ammonia gas emissions from pig farms also react with other gases in the air to form fine particle pollution and constitute a serious public health threat which has been linked to a large number of health problems including lowered lung function, cardiovascular illnesses and most seriously, premature death (Aneja *et al.*, 2008). Research has shown that as ammonia concentrations increased, so did the intensity of the odour which has resulted in an increase in the prevalence of illnesses (Jacobson *et al.*, 2002; DeBode, 1991). Previous studies done on intensive animal rearing systems have found that these levels can even exceed 500ppm (Holness *et al.*, 1989) and such levels were found to have undesirable negative effects on farm workers who were exposed to these emissions.

Hydrogen sulphide (H_2S) is another other major gas of concern due to the detrimental effects it can have on humans. It is a colourless gas with a strong scent of rotten eggs that is noticeable at concentrations as low as 0.5 parts per billion (0.0007 mg/m^3). Hydrogen Sulphide (H_2S) has been documented as one of the most important of the gases arising from the handling, storage and decay of animal waste. It is a prominent component of odorants released from confined animal feeding operations (CAFOs). The current OSHA and EMA permissible exposure limit (PEL) for H_2S is 10ppm with short term exposure limit (STEL) of 15ppm, while the NIOSH has recommended a Time Weighted Average occupational exposure limit of 10ppm. For community exposures, the Environmental Protection Agency has suggested a reference concentration of 7 ppb for long-term exposure. Simonton and Spears(2007) suggested that frequent exposure to H_2S may lead to the development of adverse symptoms such as: headache, dizziness, nausea, vomiting, coughing, difficulty breathing,and irritation of eyes, nose, and throat. High levels of exposure have also been associated with severe outcomes such as comas or death.

Schiffman *et al.*, (1995) found that H_2S has an effect on mood and neurological problems among residents living close to intensive pig operations. It has been shown that increased exposure to malodours resulted in increased levels of mood disorders such as anxiety, sleep disturbances and depression (Schiffman, 1998). Furthermore, Miner (1975) identified that odours produced can have a major effect upon a population's welfare. Unfavourable odours may cause individuals to have unpleasant sensations and major physiological effects. Residents living near pig farms have been shown to have higher impairments of mood compared to individuals living away from pig farms (Schiffman, 1998).

The present study examines the impact of malodours on the psychological well-beingof residents living near an intensive pig farming operation in Trinidad.

Materials and Methods

The target areas for the study were two research sites labelled test and control. The test area was located in a village in Erin situated within a 2000 meter radius from the intensive pig farming operation. The control area for the study was situated approximately 5000 meters from the pig farming operation. This was in the village of Palo Seco.

This study was conducted in two phases. The first phase of the study assessed the aerial emission levels of hydrogen sulphide and ammonia inthe test community using a MultiRAE gas meter. The second phase of the study investigated the effects on the psychological well-being of residents living near the farming operation using a survey methodology. Both the direct testing and the surveys were repeated in the control community located in the village of Palo Seco.

Study Area and Population

The pig farm under study has been noted to supply approximately 75% of the pork to Trinidad and Tobago's local market and contributes substantially to regional exports for this country. This farm occupies thirty two (32) acres of state land and employs 149 individuals. There were no other farming operations anywhere in the proximity and hence all emissions related to farming practices can be hypothesized to be from the study's farm operations. The Siparia Regional Corporation has administrative responsibility for the population of 81957 residents in the south western part of the country where the pig farm is located.

Air Testing: Air samples from each of the research sites were collected over a seven day period during the monthof June 2015. All samples were obtained at six hour intervals over a 12 hour period between 6:00 AM to 6:00 PM on each testing day. First sampling was always done at dawn and the last at sunset due to location of the pig farming operation;close to the coastline which experiences high humidity, wind speed and intensity at varying times throughout a given day. Therefore, the decision to begin sampling at dawn and sunset was done with the assumption that at these times, windspeeds and intensities are lower. In the test area, the first air sample was taken directly outside the pig farm with further readings being taken at 500 meter interval increments from the farm. External factors such as temperature, humidity and wind speed, prevailing winds were also recorded on testing days. All samples were measured using the multiRAE portable gas meter, which has been used to measure a wide range of volatile organic compounds, combustible gases and radiation. It isreported to be the most advance portable chemical detector and allows for efficient and effective field testing with a high precision of accuracy (Punch 2013). In this study, the meter was held two meters from the surface of the ground which was hypothesized to be representative of breathing zone for most residents residing in the research sites.The meter was calibrated on each research dayprior to recording any measurements. This study primarily measured levels for ammonia and hydrogen sulfide. These procedures were repeated in the control area.

Survey sample- A systematic judgmental sampling technique similar to that used by Punch (2013) was used for the selection of participants from both thetest and control areas. All data obtained were kept strictly confidential, and anonymity was preserved. Verbal consent was sought before any data was collected from study participants. A calculated sample size of 172 residents was determined using a 95% confidence interval, a Z value of 1.96 and a 5% margin error. The sample population was then subdivided into two groups based on the study area location; therefore each group contained 86 possible respondents (86- test; 86- control).

The test group comprised individuals aged 18 years and over living within a 2000 meter radius from the intensive pig farming operation in the village of Erin, Trinidad. The control group comprised individuals over the age of 18 years living in the same rural community, but who resided 5000 meters beyond the intensive pig farming operationin the adjoining village of Palo Seco, Trinidad. This control location was chosen because residents never reported any environmental concerns to the authorities and residents reflected similar socio-demographic characteristics as that of the residents of the test area.

Survey Instrument and administration

A structured questionnaire was used to gather information from residents of both the test and control areas. The questionnaire consisted of questions related to general socio-demographics, questions to assess psychologicalwell-being health, and questions assessing the impact of malodours on residents' everyday life. Questionnaires were pretested with ten individuals in the test area, and after recommended revisions were administered over a period of 4 week period by trained data collectors. The response rate to the questionnaires was high; with a completion rate of 80%. The main reason givenfor not participating in the interview was that the farm employs members of their families and they did not want to participate in any activity that may cause the farm to close.

Psychological well-being was assessed in the narrow sense of mood disturbance using sixty five (65) questions based on the Profile of Mood State (POMS) measure. The POMS has been known to be highly sensitive standardized scale (Nyenhuis *et al.*, 1999). POMS have been used with persons at risk for disorders due to high toxic exposures. It has been used by the World Health Organization to examine the effects of environment and industrial toxins on workers, and also used in the evaluation of mood changes in response to odour by neighbours of swine operations in North Carolina.

Respondents were asked to respond to these 65 questions and each response was recorded on a five point response scale from 0(not at all) to 4 (extremely). Moods which were assessed were that of Tense, Unworthy, Gloomy, Angry, Uneasy, Sluggish, Worn out, Fatigued, Weary, Lively, Annoyed, Bewildered, Confused, Discouraged, Furious, Shaky, Nervous, Efficient, Sad, Lonely, Full of pep, Active, Muddled, Bad tempered, Grouchy, Exhausted, Forgetful, Energetic, Anxious, Vigorous. Responses were categorised into 6 different aspects of transient mood types, namely, anger-hostility; confusion-bewilderment; depression- dejection; fatigue inertia; tension-anxiety and vigour- activity. A high score in the POMS measure would indicate to poorer quality of life.An example of a question would be: In the past week have you felt friendly?

A psychologicalwell-being score for each respondent was computed by summing the scores obtained from the frequency of moods experienced. Individual scores could range between 0- 260.

Malodour impact was assessed using four questions which sought to rate the extent of the impact of malodours on residents. Questions focused on odour irritation, intensity, impact on well-being and intensity. The four statements were: How would you describe the odour?; How intense is the odour?; Is the odour irritating?; How much does the odour affect our everyday life?". Each response was measured using a four pointrating scale and summated to given an overall malodour impact score. Response categories were: Never (Score =1); sometimes (score = 2, and often (score=3). Individual scores ranged between 4-12. A similar scale was used previously investigating the relationship between foul odours among non-famers (Schiffman, 1995). Higher scores were indicative of a higher impact experienced to the malodours and lower scores reflected a lower impact.

Statistical Analysis

Data were analysed using SPSS v21. Means and standard deviations were used to describe continuous outcomes while percentages were used for categorical outcomes. Comparisons of the levels of ammonia and hydrogen sulfide levels between the control and test areas were assessed using a paired sample t test. Differences between socio-demographic and lifestyle variables were assessed using the Pearson Chi-square test.Unadjusted and adjustedmultiple linear regression models were constructed with gender, age, smoking habit, length of time living in the area, time spent outdoors and malodour intensity score to examine their influence on the psychological wellbeing of respondents.

RESULTS

Study Area Analysis

A paired t test was used to compare the values of ammonia and hydrogen sulfide found in the test and control areas. In the test area, the means for NH_3 and for H_2S was 0.92 ppm and 1.19ppm respectively, whereas the means for both gases in the control area were recorded at 0. Results thus indicate a significant difference in levels between the test and the control area (data not presented).

Description of Study Population

The study population comprised 172 participants equally distributed (n= 86) between study area sites. The majority of the sample (Table 1) was under the age of 39 years with most participants living in their area for over 20 years, did not smoke and who spent more than 3 hours per day outside their homes. There were no significant (p>0.05) differencesbased on Wald and chi-square tests between socio-demographic factors across study areas.

Differences in Psychologicalwell-being Characteristics across study areas.

Table 2 presents the psychological well-being characteristics scores, derived using the POMS,

Table 1. Socio-demographics of Study Population by Study Area (n=172)

Variables	Test Arean (%)	Control Arean (%)	p-value
Gender			
Male	40 (46.51)	45 (52.33)	
Female	46 (53.49)	41 (47.67)	0.446
Age			
18-28	30 (34.88)	22 (25.58)	
29-39	29 (33.72)	29 (33.72)	
40-50	19 (22.09)	28 (32.56)	
>50	8 (9.31)	7 (8.14)	0.388
Smoking Status			
Smoker	34 (39.53)	23 (26.74)	
Non-Smoker	52 (60.47)	63 (73.26)	0.075
Length of time living in area			
Less than 1 year	6 (6.98)	10 (11.63)	
1-10 years	7 (8.14)	4 (4.65)	
11-20 years	24 (27.91)	33 (38.37)	
>20 years	49 (56.97)	39 (45.35)	0.224
Time spent outdoors			
Two hours	20 (23.26)	10 (11.63)	
Three hours	32 (37.21)	36 (41.86)	
> Three hours	34 (39.53)	40 (46.51)	0.132

across participants residing in different study area sites as well as significant differences tests. Some 65 items were assessed and these werecategorized into six transient mood types:anger-hostility; confusion-bewilderment; depression- dejection; fatigue-inertia; tension- anxiety and vigour- activity. Individual scores ranged as follows: anger- hostility (0-48), confusion-bewilderment (0-40), depression-dejection (0-56), fatigue- inertia (0-36), tension-anxiety (0-36), and vigour- activity (0-44).

Results showed that participants residing in the test area reported significantly ($p<0.05$) higher symptom rating scores for tension-anxiety, depression-dejection, anger-hostility, confusion-bewilderment, fatigue-inertia and total mood disturbance compared to participants residing in the control area. A significantly higher score ($p<0.05$) was seen in the control area for vigour-activity compared to the test area.

Linear Regression of Mood profile on selected characteristics

Table 3 presents the simple multiple linear regression models which describes the relationship between explanatory variables and psychological well-being. Unadjusted models showed a positive association between psychological well-being scores and malodour scores (β= 4.970; p=<0.001). In the adjusted model; it was observed while controlling for study area location, smoking status age, and gender, there was a non-significant relationship between malodour rating score and mental health scores (β= 0.857; p=0.233). Females were seen to have significantly reduced rating for their psychological well-beingas compared to their male counterparts (β= -5.430; p=0.043).Individuals residing in the test area were also seen to have a significant positive association with a higher adverse of psychological well-being symptoms compared with persons residing in the control area (β= 49.428; p=<0.001).

DISCUSSION

This study sought to investigate the association between malodour exposure and psychological

Table 2. Differences in Mood Scores of participants in study areas

Mental Health Characteristics	Test Area (n=86) Means (SD)	Control Area (n=86) Means (SD)	P value
Tension- anxiety	17.36 ± 7.46	8.22 ± 5.41	<0.001
Depression-dejection	25.99 ± 12.56	14.85 ± 10.60	<0.001
Anger-hostility	21.90 ± 8.60	10.70 ± 7.84	<0.001
Vigour-activity	9.19 ± 5.30	21.30 ± 5.93	<0.001
Confusion-bewilderment	16.5 ± 3.83	8.34 ± 5.14	<0.001
Fatigue-inertia	16.27 ± 5.37	9.36 ± 5.33	<0.001
Total Mood Disturbance Score	88.83 ± 20.20	30.65 ± 15.25	<0.001

*p<0.05

Table 3. Linear Regression of Selected socio-demographic factors and Malodour Rating score on Mood Profile

Variable	Unadjusted β	p-value	Adjusted β	p-value
Malodour Rating Score	4.970	<0.001*	0.857	0.233
Gender				
Male	Reference		Reference	
Female	-8.47	0.105	-5.430	0.043*
Age (years)				
18-50	Reference		Reference	
>50	-6.505	0.528	-5.134	0.342
Smoking Status				
No	Reference		Reference	
Yes	-6.88	0.228	1.483	0.610
Study Area				
Control	Reference		Reference	
Test	58.170	<0.001*	49.428	<0.001*

*p<0.05

well-being among individuals residing near pig-farming operations in a rural community in Trinidad. Hydrogen sulphide levels were seen to be substantially larger compared to ammonia, and exposure to both malodours appeared to impact themood profile of residents.

High levels of hydrogen sulphide may have been linked to the anaerobic breakdown of waste after it is placed in the waste pond at the farm (El-Fadel *et al.,* 1997). The study found that the further the distance from the farm, the lower the concentration of gases became, hence it can be reasonably concluded that the gases were emanating from the farm itself since there were no similar activities in the control area and it was in fact the cause of the malodour. To further support this suggestion, there were no gases or odours presentthe control community of Palo Seco.

Ammonia when compared with Time Weighted Average (TWA) of 25ppm for it was below the TWA, however it was way above the Agency for Toxic Substance and Disease Registry (ATSDR) recommended long term Maximum Residue Limit of 300ppb for community exposure. Shendrikar *et al.,* (2006) measured the ambient NH_3 surrounding a hog operation in North Carolina and found that the average ammonia levels for a five year period were between 0.002 to 0.015 ppm. This was also well below Acceptable Ambient Level (AAL) of 3.03 ppm which was used as their reference value. NH_3 reacts with particulate matter in the air and hence aerial concentration may be diminished. In this study, the ammonia levels found in the test area were also below the reference value from previous studies. Therefore, the values which were found were not at levels which may have warranted undue harm among nearby residents.

Hydrogen Sulphide when compared to permissible level of 10ppm with a measurement value of 1.29ppm. This also showed that the H_2S levels are substantially lower than the exposure limit however they too are above the ATSDR recommended long term limits of 7 ppb. Van Aalst *et al.* (2000) found that H_2S has a low odour threshold of less than 1ppm therefore the levels of H_2S were not very high (1.29ppm) in the test area. It was still over the odour threshold meaning that malodours would be detectable by the residents in the area. This suggests that although the ammonia and hydrogen sulphide levels are below NIOSH levels, they are still present in the atmosphere and would produce malodours. The detection of the odour itself is a marker of the social standing of the community. Odour disrupts life and can also cause changes in a person's health and mood (Schiffman 1994). The levels of hydrogen sulphide found in our study was also lower to that of the recommended threshold levels, which suggests that this emissions may not have any meaningful impact on the health of nearby residents.

The findings found in this study with respect to the relationship between malodour exposure and psychological health were similar to those reported in previous studies. Schiffman *et al.* (1995) found in their study of odour from pig farming on the mood of residents in North Carolina discovered that odour negatively affects the mood of residents. They found that all scores for anger, depression, confusion, tension, and fatigue were all higher in populations exposed to malodours from intensive pig farming with the score for vigor being higher for those not exposed to malodours.

The Trinidad and Tobago Occupational Safety and Health Act (2004), gives the responsibility to industries to protect the health, safety and welfare of employees and others who may be affected by their operations. The act specifically speaks about health surveillance and medical examinations but those remain for employees; however does not address surrounding communities.

The Environmental Management Agency (EMA) of Trinidad and Tobago on the other hand, monitors the emissions from the farm but the exposure levels to workers who are in direct contact to the emissions are not measured. These monitoring methods also do not take into account the impact of these odours on residents who are exposed to lower doses of gases over a long period of time. Furthermore, the EMA and OSHA acts fail to address any regulatory methods to aid in regulating the malodours in Trinidad.

There are several actions that the farm could take to greatly reduce the amount of emissions and consequently diminish the malodors. These would relieve the EMA concerns and also address some of the OSH problems in and around the farm; however, these methods are expensive to implement and maintain and the farm owner may not be willing to implement these changes unless compelled by strict regulations.

Famers and residentsalso need to be educated on the possible effects that malodour and emissions could have on their health and general well-being. They should also be educated about proper sanitation practices and should begin to become more aware of their general health.They should be empowered to take actions on their own to secure their general well-being.

CONCLUSION

High levels of ammonia and hydrogen sulphide was found to be present in the test community of Erin however it was not over the Time Weighted Average. The average concentrations of each gas were identified as 0.92 ppm for ammonia and 1.18ppm for hydrogen sulphide. The odour impacted the psychological well-being of residents living close to the farm and this was expressed in disturbances of their moods. While the farm owners need to introduce some modern practices to significantly lessen the odour, appropriate legislation and regulations are required by governmental agencies in helping to reduce the high levels of exposure experienced by these residents. Legislative actions, along with proper monitoring and enforcement by the Environmental management Agency will help not only the residents of Erin but also residents across the country who may be similarly impacted by negative environmental effects of large scale farm operations.

REFERENCES

Allen, A.G., Harrison, R.M. and Wake, M.T. 1988. A meso-scale study of the behavior of atmospheric ammonia and ammonium. *Atmospheric Environment* 22 : 1347-1353., accessed May 23rd, 2015

Aneja, V.P., Chauhan, J.P. and Walker, J.T. 2000. Characterization of atmospheric ammonia from swine waste storage and treatment lagoons. *Journal of Geophysical Research* 105 : 11535-11545., accessed May 23rd, 2015

Aneja, V.P., Schlesinger, W.H. and Erisman, J.W. 2008. Farming pollution. *Nature Geoscience*. 1 (7) : 409-411.

ApSimon, H.M., Kruse, M. and Bell, J.N.B. 1987. Ammonia and their role in acid deposition. *Atmospheric Environment* 21 : 1939-1946, accessed May 23rd, 2015

Battve, R., Battye, W., Overcash, C. and Fudge, S. 1994. Developments and selection of ammonia emissions factors: Final Report". EC/R Inc., Durham, NC. EPA Contract Report #68-D3-0034, U.S. Environmental Protection Agency, Research Triangle Park, NC. 111 pp, accessed May 23rd, 2015

Bundy, D.S. 2016. Odor issues with wastes. In national livestock, poultry and aquaculture waste management. *Proceeding of the National Workshop* 199. ASAE Publication 03-92; St Joseph, MI: American Society of Agricultural Engineers 1992: 288-292, accessed March 2nd, 2016.

Cox, James. P. 2016. *Odor Control and Olfaction: Handbook.* Lynden, WA: Pollution Sciences Company; 1975: l - 490., accessed March 2nd, 2016.

De Bode, M. J. C. 1991. Odor and ammonia emissions from manure storage. In: *Ammonia and Odor Emissions from Livestock Production,* eds. V.C. Nielsen, J. H. J. H. Voorburg, and P. L'Hermite, 59-66. London: Elsevier Applied Sciences Publisher., accessed May 23rd, 2015

El-Fadel, M., Findikakis, A.N. and Leckie, J.O. 1997. Environmental impacts of solid waste landfilling. *Journal of Environmental Management*. 50(1) : 1-25.

Griffin, R.D. 2006. *Principles of Air Quality Management*. CRC Press.

Heimlich, L.B.R.E. 2001. Development at the Urban Fringe and Beyond: Impacts on Agriculture and Rural. *Economic Research Service, Washington DC: US Department of Agriculture.*

Hobbs, P. J., Pain, B. F., Kay, R. M. and Lee, P. A. 1996. Reduction of odorous compounds in fresh pig slurry by dietary control of crude protein. *Journal of the Science of Food and Agriculture.* 71 : 508-514. accessed May 23rd, 2015

Ilea, Ramona Christina. Intensive Livestock Farming: Global Trends, Increased Environmental Concerns and Ethical solutions. 2008. *Journal of Agriculture and Environmental Ethics.* 22: 153-167. accessed March 2nd, 2016.

Iowa State University and the University of Iowa Study Group. 2002. "Iowa concentrated animal feeding operations air quality study- Final Report. https://www.public-health.uiowa.edu/ehsrc/CAFOstudy/CAFO_1.pdf(accessed 15/06/2015)

Jacobson, L.D., S.L. Wood-Gay, D.R. Schmidt, A.J. Heber, J.R. Bicudo, and R.D. Moon. 2002. Site Selection of Animal Operations Using Air Quality Criteria. White paper and Recommendations. National Center for Manure and Animal Waste Management, North Carolina State University, Raleigh, N.C. 39 p., accessed May 23rd,2015

Koerkamp, P.G., Metz, J.H.M., Uenk, G.H., Phillips, V.R., Holden, M.R., Sneath, R.W., Short, J.L., White, R.P.P., Hartung, J., Seedorf, J. and Schröder, M. 1998. Concentrations and emissions of ammonia in livestock buildings in Northern Europe. *Journal of Agricultural Engineering Research*. 70 (1) : 79-95.

Kurvits, T and T. Marta. 1998. Agricultural NH3 and NOx in Canada. *Environmental Pollution.* 102(Sl): 187-194., accessed May 23rd, 2015

Miner, J.R. 1975. Management of Odors Associated with Livestock Production. 34d *Int. Sym. On Livestock Wastes.* ASAE Publication No. PROC-275. , accessed May 23rd, 2015

Nyenhuis, D.L., Yamamoto, C., Luchetta, T., Terrien, A. and Parmentier, A. 1999. Adult and geriatric normative data and validation of the profile of mood states. *Journal of Clinical Psychology*. 55(1) : 79-86.

Punch, K.F. 2013. *Introduction to Social Research: Quantitative and Qualitative Approaches*. Sage.

Reynolds, S.J., Donham, K.J., Stookesberry, J., Thorne, P.S., Subramanian, P., Thu, K., Whitten, P. 1997. Air quality assessments in the vicinity of swine production facilities. In: Agricultural Health and Safety: Recent Advances (Donham KJ, ed). Binghamton, NY: Haworth Press, Inc. 37-45. accessed March 2nd, 2016.

Ritter, William, F. Odor control of livestock wastes: State-of-the-art in North America. *J. Agric. Eng. Res.* 42:5 l-62; 1989 , accessed March 2nd, 2016.

Schiffman, Susan, S. 1998. Livestock odors: implications for human health and well-being. *Journal of Animal Science*. 76(5) : 1343-55. Review. PMID: 9621940, accessed March 2nd, 2016.

Schiffman, Susan S., Elizabeth A., Sattely Miller, Mark S. Suggs and Brevick G. Graham. 1994. The Effect of Environmental Odors Emanating From Commercial Swine Operations on the Mood of Nearby Resident. *Brain Research Bullentin.* 3 (4) : 369-375.

Schiffman, S.S., Miller, E.A.S., Suggs, M.S. and Graham, B.G. 1995. The effect of environmental odors emanating from commercial swine operations on the mood of nearby residents. *Brain Research Bulletin.* 37(4) : 369-375.

Shah, K.U. and Rivera, J.E. 2007. Export processing zones and corporate environmental performance in emerging economies: The case of the oil, gas, and chemical sectors of Trinidad and Tobago. *Policy Sciences*. 40(4) : 265-285.

Shendrikar, Arun D., Joette Steger, Hoke Kimball, Wayne Cornelius, Mark Yirka, Robert Bishop and Neil Joyner. 2006. Atmospheric ammonia monitoring around hog farm industries in North Carolina. North Carolina Division of Air Quality.*http://daq.state.nc.us/monitor/projects/* (accessed June 30th, 2015)

Sierra Club. 2015. Confined Animal Feeding Operation Fact Sheet, Michigan Chapter http://www.sierraclub.org/michigan/cafo-facts (accessed July 21st, 2015)

Simonton, Scott and Morgan Spears. 2007. Human Health Effects from Exposure to Low-Level Concentrations of Hydrogen Sulfide.

Sommer, S. G. and Hutchings, N. 1995. Techniques and strategies for the reduction of ammonia emissions from agriculture. *Water, Air and Soil Pollution*. 85 : 237-248., accessed May 23rd,2015

Van Aalst, J.A., Isakov, R., Polk, J.D., Van Antwerp, A.D., Yang, M. and Fratianne, R.B. 2000. Hydrogens ulfide inhalation injury. *Journal of Burn Care Rehabilitation* 21 : 248-253.