Research Article

Assessment of air quality in Dammam slaughter houses, Saudi Arabia

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Abstract

Background: Air pollution, both indoor and outdoor, is often considered as one of the major causes of environmental health problems. Usually, air in slaughterhouses is heavily contaminated by large quantities of dust particles of biological and nonbiological origin, toxic gases, and odors. However, the quality of indoor air in slaughterhouses was rarely investigated.

Objective: To evaluate the slaughterhouse indoor environment parameters such as particulate, toxic gases, and bioaerosol levels.

Materials and Methods: Indoor and outdoor air quality parameters CO, O_3, CO_2, VOCs, PM_{10}, $PM_{2.5}$, SO_2, and NO_2 were measured using references calibrated air sampling devices. Microbial air samples were taken using Staplex air sampler. To assess indoor air quality in Dammam slaughterhouse, air samples were taken from two different laboratories.

Result: All mean levels of CO_2 inside all slaughterhouse laboratories were higher than their Air Quality Guidelines value, which is recommended by the World Health Organization and in Europe. Indeed, the average levels of NO_2 and CO were lower than their AQGs. However, the mean levels of SO_2 and VOCs were significantly exceeding the air quality guidelines. Bioaerosols examination using Staplex air sampler indicated that limited number of bacterial and fungal strains contaminate slaughterhouse air in the two laboratories. In comparison with laboratory A, the 44.2% reduction in total viable bacterial count, as compared with laboratory B, reflected the better hygienic standards followed in this new laboratory. Colony count remains constant after 5 and 10 min with approximately 25 CFU/m^3 near director's offices due to limited working activities.

Conclusion: Location of slaughterhouse close to second industrial city of Dammam was significantly having serious impact up on indoor and outdoor air quality data. Indeed, slaughterhouses environment should be controlled for bioaerosol production and bacterial contaminations through good and efficient ventilation system.

KEY WORDS: Air quality, Dammam, slaughterhouses, bioaerosol, air pollution

Introduction

Protection of the human health in many sectors attracted attention of different governments and policy makers in several countries with special concern to public awareness. Recently, special considerations are given to slaughterhouses due to several health hazards problems related to the hygienic quality and microbiological specifications of the produced meats. It is well known that air pollution is considered as one of the major causes of pollution. Although, intensive studies were carried out to unravel the major causes and health hazardous effects of outdoor air pollution, little was conducted concerning indoor air quality (IAQ) and its tight relation with sick building syndrome.[1,2] Interestingly, indoor environment commonly produce amount of air pollutants, such as particulate matter (PM) and bioaerosols. Exposure to air pollutants such as organic dusts, in many poultry and animal slaughterhouses,

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increase the risk for many pulmonary diseases.[3,4,5] Furthermore, indoor environment can be considered as more hazardous than the outside environment, because enclosed spaces can limit or restrict aerosols and thus increases to the limit of infectious doses. Furthermore, improper maintenance of heating, ventilation, and air conditioning system can dramatically increase the hazardous effect of many biological and nonbiological pollutants.

In closed buildings, increase risk of respiratory and cardiovascular diseases is mostly due to indoor air pollutants. Therefore, public awareness especially to food safety in slaughterhouses is becoming a major request for administrative authorities and environmental scientists.[6] Many studies on microbial contaminants in indoor air have been recorded in different environments such as hospitals, schools, museums, cows and cattle buildings, suburban environment, and office environments.[7]

However, the quality of indoor air in slaughterhouses was rarely investigated. Few attempts have been made to assess the air quality status of slaughterhouses from the chemical point of view, namely; the exposure of slaughter workers to nitrous oxide and sulfur dioxide. Recently, the concentration levels of respirable PM, carbon dioxide (CO_2), and volatile organic compounds (VOCs) in slaughterhouses, and estimated emission rates of indoor sources are closely investigated.[8,9]

The health risk due to production of fungal toxins isolated from different sites in slaughterhouses was reported by many scientists.[10,11] Although extensive studies have been carried out to address the major microbial contaminants associated with processing of meat in poultry houses,[12,13] limited studies were carried out on IAQ.[12,13,14,15]

The main aim of the study was to assess IAQ as well as microbiological contaminates in slaughterhouse in Dammam, Saudi Arabia. Emphasis was given to evaluation of the IAQ through estimation of some known indicators of indoor air pollutants namely; SO_2, carbon monoxide (CO), VOCs, ozone (O_3), nitrogen dioxide (NO_2) and CO_2, and particulate matter fractions (PM_{10}, PM_4, $PM_{2.5}$, and PM_1) levels.

Materials and Methods

Sampling, Enrichment and Isolation

Bioaerosol air samples were collected from two laboratories (A and B) within the slaughterhouse in Dammam, Saudi Arabia suing Staplex air sampler. Air samples from different sites were collected after 5 and 10 min in the two laboratories. For isolation of bacteria, nutrient agar medium was used (g/L); peptone 5; beef 3; NaCl 5, and agar 15 whereas fungi were isolated by plating on Sabouraud destrose agar medium (oxoid).

Monitoring Air Quality

The air quality of slaughterhouses workplace was monitored inside and outside the area to establish the existing workplace air quality status, which include the impact of operations of plant. Sampling stations were identified based on the site survey to get entire coverage of surroundings. Meteorological sensors (wind speed and direction, air temperature, pressure, and humidity) were measured.

Four air pollutants were measured during this study including: PM_{10} that was measured in micrograms per cubic meter (μg/m^3), SO_2, CO, VOCs, O_3, NO_2, and CO_2 which were measured in parts per million (ppm). At each sampling station, 25 readings (over 2-h period) were directly recorded on the basis of 5 min averages for each gaseous pollutant at morning and noon time. Therefore, in this study, there were 6000 records for each of the NO_2, VOCs, O_3, SO_2, CO, CO_2, and PM_{10} levels.

Collected samples were then analyzed by standard methods for computation of concentrations of SO_2, NO_2, VOCs, CO, and CO_2. The EntryRAE (PGM-3000) Multi-Gas Monitor was used for measurement of CO_2 and the VRAE Hand Held 5 Gas Surveyor (Model 7800 Monitor) was used for measurement of NO_2, SO_2, O_3, and CO. PM_{10}, PM_4, $PM_{2.5}$, and PM_1 were sampled on 60-mm diameter glass fiber filters by the pre-calibrated hand-held battery portable air sampler based on 2-h samples. Gravimetric determination and calculation of PM_{10} concentrations were in μg/m^3. 8-h gravimetric measurements of PM_{10} concentrations took place at three different sites of the slaughterhouses. NO_2, CO, CO_2, and SO_2 levels were automatically monitored.

Result

Assessment of Indoor Microbial Contaminates

To study bioaerosol levels in the two laboratories, nutrient agar and Sabouraud dextrose media were used for isolation of bacteria and fungi, respectively. Results indicated that limited number of bacterial and fungal strains contaminate slaughterhouse air in the two laboratories. Furthermore, total bacterial count by heterotrophic plate count method, after 10 min in laboratories A and B, was approximately 77 and 43 CFU/m^3, respectively. In comparison with laboratory A, the 44.2% reduction in total viable bacteria in laboratory B refrects the better hygienic standards followed in this new laboratory. Interestingly, it is to be mentioned that colony count remains constant after 5 and 10 min with approximetly 25 CFU/m^3 near directors offices due to limited working activities as well as the use of air conditioners.

Monitoring of Air Quality in Dammam Slaughterhouse

Results recorded in Table 1 indicate that the mean levels of CO, CO_2, O_3 indoor and outdoor, either morning or noon measured concentrations, were lower than air quality guidelines. However, the mean levels of SO_2 as well as levels of VOCs in outdoor and indoor were found to slightly exceed the air quality guidelines and these might be the traffic and sourrounding industrial emmissions.

On the other hand, the mean levels of particulate fractions (PM_{10}, PM_4, $PM_{2.5}$, and PM_1) recorded in Table 2 significantly exceed the air quality guidelines.

Also, meteorological parameters recorded in Table 3 indicated that dispersion of pollutant was significantly affected by

Table 1: Mean levels of indoor and outdoor gasesous air parameters in slaughterhouse

Location	Time	CO ppm	CO_2 (ppm)	NO_2 (ppm)	SO_2 (ppm)	VOCs (ppm)	O_3 (ppm)
Indoor	Morning	0.46	963	0.12	0.46	1.02	0.01
	Noon	0.73	773	0.12	0.43	0.57	0.01
Outdoor	Morning	0.41	945	0.19	1.46	1.03	0.02
	Noon	0.53	780	0.11	0.66	0.65	0.01

Table 2: Mean levels of particulate matters fractionations in Dammam slaughterhouse (morning and noon time)

Location	Time	PM_{10} ($\mu g/m^3$)	PM_4 ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	PM_1 ($\mu g/m^3$)
Indoor	Morning	403	175	192	240
	Noon	306	184	192	200
Outdoor	Morning	442	133	104	179
	Noon	385	155	198	106

Table 3: Meterological factors in Dammam slaughterhouse

Location	Time	Temp (°C)	Humidity (%)	Wind speed (km/h)
Indoor	Morning	26.8	42.3	1.26
	Noon	39.3	38.4	1.40
Outdoor	Morning	40.4	23.3	2.86
	Noon	44.2	22.6	2.36

the variability in wind direction, wind speed as well as relative humidity, and temperature levels. Interestingly, those factors are well known to modify air quality monitoring methodology.

Discussion

Assessment of bioaerosol level in two different laboratories in slaughterhouse of Dammam city indicated that limited strain of bacteria and fungi can be isolated. However, several bacterial strains can be isolated from air by cultivation on nutrient agar media. Moreover, few fungal strains were isolated from the same sources by cultivation on Sabouraud dextrose agar media. It is essential to keep concern about the airborne bacteria in slaughterhouses because they clearly impact the meat. Rahkio and Korkeala[16] found that airborne bacteria have an important role in carcass contamination. Interestingly, several bacterial and yeast-like fungal strains were isolated from bioaerosol environment of slaughterhouses in South Africa and Serbia.[17,18] Moreover, the dominance of yeast-like fungi as well as some dermatophytes in the air of many slaughterhouses was a great sign for the potential risks to human health.[19]

Air pollution occurs when concentrations of one or more air pollutants exceed the desirable levels and air quality is corrupted. Large qualities of aerial pollutants can be generated from animal feeding operations (AFOs) in many facilities.[8]

Various air pollutants can be produced from livestock and poultry buildings, and on-site manure storage and treatment facilities, causing dramatic air pollution. These pollutants can generally be classified into four groups: fixed gases or gases, odors, PM, and VOC.[8] The main pollutant gases from AFOs include ammonia (NH3), hydrogen sulfide (H_2S), methane (CH_4), nitrous oxide (N_2O), and CO_2. Ammonia and H_2S are the most recognized hazardous substances that are produced from animal wastes.[19]

On the other hand, air pollution results from the manufacturing unit in industrial city of Dammam that release significant amounts of gases emissions and compounds including CO, CO_2, PM, SO_2, NO_2 particles, and VOCs. Moreover, industry and transport are the two primary sources of air pollution in Saudi Arabia.[20]

It is well known that air in most indoor environments contains a variety of particles and gaseous contaminants. These contaminants are commonly referred to as indoor air pollutants. From the health point of view, the most important indoor air pollutants are dust (or PM), carbon monoxide (CO), SO_2, NO_2, and volatile organic compounds. The CO_2 concentrations generally encountered in buildings have no adverse health effects. However, the concentration of these pollutants mostly related to the ventilation rate relative to the number of occupants and building volume.[20] On the other hand, particulates and gaseous emission of pollutants from industries and auto-exhaust are responsible for rising discomfort, increasing airway diseases, decreasing productivity, and deterioration of

air quality in surrounding environment. In slaughterhouse area more than 70% of the emission of main contaminants came from mobile sources. The main industrial areas are located close to the slaughterhouse contributing to the other 30%.[21]

For monitoring the impact of primary industrial particulate emissions on air quality since major ambient air particles derived from these emissions are mainly in the range of 2.5–10 m. Air pollutants that originate in the outdoor atmosphere from automobile and factory emissions and other combustion processes are likely to be present indoors. In the absence of indoor sources of these pollutants, concentrations indoors will be close to or lower than those outdoors.[22]

IAQ inside slaughterhouse are adversely affected, depending on their locations relative to the outdoor sources of air pollution, particularly traffic activity and industrial emissions. All mean levels of CO_2 inside all slaughterhouses were higher than its Air Quality Guidelines value, which is recommended by the World Health Organization and in Europe. The average levels of SO_2, NO_2, and CO inside all selected slaughterhouses were lower than their AQGs. However, the mean levels of SO_2 and VOCs significantly exceed the air quality guidelines. These results reflect the relative bad IAQ in the slaughterhouses of Dammam city, which is considered as an important and a representative city for the eastern province of KSA, due to the inefficient rate of ventilation and absence of environmental awareness. The concentration of the parameters at different time of the day is highly influenced by the variation in the temperature of Dammam where the study area is located. In concordance study, it is reported that results of the comparison between the survey data and the FEPA limit show that PM, SO_2, NO_2, and chlorine are slightly above the FEPA limit.[23–25]

The area of an industrial town located 25 km west of Dammam, has been an object of concern because of several sources of environmental and occupational contamination potentially affecting the residential communities: a harbor, and different industrial plants are present in the area. According to our calculations and the monitoring measurements, the influence of the industrial sources and traffic activities over the slaughterhouse area, exceed the air quality standard.

Conclusion

According to our calculations and the monitoring measurements, the influence of the industrial sources and traffic activities over the slaughterhouse area, exceed the air quality standard. Location of slaughterhouse close to second industrial city of Dammam is significantly having serious impact up on indoor and outdoor air quality data. Slaughterhouses environment should be controlled for bioaerosol production and bacterial contaminations through good and efficient ventilation system and application of full hygienic standards.

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