Base de Conhecimentos Gerados na Engenharia Ambiental e Sanitária 2

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(Organizador)

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CAPÍTULO 17

MEASUREMENT AND MATHEMATİCAL MODELLİNG OF ODOR GASES İN A COLLAGEN AND GELATİNE PLANT

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ABSTRACT*:* The objective of this study was to identify and quantify odor sources throughout the production process of a gelatine and collagen factory located in the interior of Paraná State, Brazil. At the same time, an atmospheric dispersion model was used to identify the radius of coverage and the frequency of perceived values of odor around the company and, thus, propose improvements of control systems or installation of new systems. The NH_3 (ammonia) and H_2S/CH_4S gases (hydrogen sulphide/methyl mercaptan) were measured during 7 consecutive days around emission sources and throughout the company's production process. Thus, the monitoring was performed on the arrival of the trucks with the used raw material (bovine hides), loading of storage hopper, storage shed and effluent treatment station. Electrochemical, automatic and continuous measurement Cairpol's sensors were used. This equipment records the measurements in ppb (part per billion) every minute and stores them in an internal data logger. During the monitoring period, an anemometer was installed to record wind direction and wind speed data every 5 minutes to correlate with gas measurements. After identification and quantification of odors sources the atmospheric dispersion mathematical model AMS/USEPA AERMOD was implemented. The model requires the following input data: meteorological, topographic, soil use of the study region and gases emission rate for emission sources. The emission rates of non-point sources were estimated using a reversed modeling method. The results of gases measurement showed that the largest sources of emissions are concentrated in the storage hopper, storage sheds, industrial effluent treatment plant and the biofilter outlet used to treat the gases from one of the storage sheds. The mathematical simulation showed that under unfavorable conditions for pollutants dispersion, it is possible to smell H_2S/CH_4S within a radius of approximately 5 km from the company. For the NH_3 this radius is 1.5 km for all people with average sensitivity to odors. A hypothetical scenario was created considering a reduction of 80% in the emission of the gases from the biofilter, process and storage and of 50% from the treatment plant, based on the propositions made for adjustment and implementation of new control systems. This future scenario indicated a decrease in the NH_3 perception radius to approximately 200 meters from the company and 4 km for H_2S/CH_4S in the worst conditions of gases dispersion for the simulated period.

KEYWORDS: Odour, odour monitoring, mathematical air dispersion modeling, odour sensors.

RESUMO: O objetivo do estudo foi identificar e quantificar as fontes de odor em todo o processo produtivo de uma fábrica de gelatina e colágeno, localizada no interior do Paraná, Brasil. Paralelamente foi empregado um modelo matemático de dispersão de gases odoríferos para identificar o raio de abrangência e a frequência de valores perceptíveis de odor no entorno da empresa e, desta forma, propor melhorias nos sistemas de controle ou instalação de novos sistemas. Os gases NH3 (amônia) e H2S/CH4S (sulfeto de hidrogênio/metilmercaptana) foram medidos durante 7 dias consecutivos no entorno das fontes de emissão e em todo o processo produtivo da empresa. O monitoramento foi realizado na chegada dos caminhões com a matéria prima utilizada (couros de bovinos), no carregamento das moegas, galpão de armazenamento e na estação de tratamento de efluente (ETE). Foram utilizados sensores eletroquímicos automáticos e de medição contínua, da marca Cairpol, que possuem bateria interna e capacidade de armazenamento de dados a cada minuto e fornecem medições em ppb (parte por bilhão). Durante o monitoramento foi instalado um anemômetro para registrar os dados de direção e velocidade do vento a cada 5 minutos, com o intuito de correlacionar com as medições dos gases. Após identificação e quantificação das fontes de odor foi feita a implementação do modelo matemático de dispersão atmosférica AERMOD, da AMS/USEPA. O modelo matemático requer como dados de entrada: dados meteorológicos, topográficos e uso do solo da região de estudo, além de dados da taxa de emissão dos gases das fontes de emissão. As taxas de emissão de fontes não pontuais foram estimadas empregando um método de modelagem reversa. Os resultados das medições dos gases mostraram que as maiores fontes de emissão estão concentradas na moega, barracões de armazenamento, estação de tratamento de efluentes industriais e na saída do biofiltro utilizado para tratar os gases de um dos barracões de armazenamento. A simulação matemática mostrou que em condições desfavoráveis à dispersão de poluentes é possível sentir odor de H2S/CH4S em um raio aproximado de 5 km da empresa. Para o NH3 este raio é de 1,5 km para todas as pessoas com sensibilidade odorífera média. Foi criado um cenário hipotético considerando uma redução de 80% de emissão dos gases no biofiltro, processo e armazenamento e de 50% para ETE, baseado nas proposições feitas para ajuste e implementação de novos sistemas de controle. Este cenário futuro indicou uma diminuição do raio de percepção de NH3 para aproximadamente 200 metros da empresa e de 4 km para H2S/CH4S, nas piores condições de dispersão de gases para o período simulado.
PALAVRAS-CHAVE: Odor, monitoramento de odor, modelagem matemática atmosférica, sensores de odor.

INTRODUCTION

Odor emitted by industries are the major sources of environmental pollution related claims for air pollution (Henshawet et al., 2006). Odor is the olfactory response of humans to odorous gases, indicating that it is a subjective sensation, with individual characteristic. Odor emissions are a nuisance to neighboring communities due to bad smell and potential health hazards. However, they are rarely monitored on an ongoing basis due to the limitations of the techniques and the lack of legislation. Odoriferous substances can usually be grouped into three groups: sulfur compounds (hydrogen sulphide, mercaptans), volatile organic compounds and nitrogen-containing compounds (ammonia, amines) (Schifimann, 2001). In several processes some compounds are dominant over the odor, indicating the total odor concentration, as they are present in higher concentrations than other odorants and can be detected in low concentrations through continuous measurement equipment (Karageorgos, 2010). Hydrogen sulfide (H_2S), mercaptans (CH_4S) and ammonia (NH_3) are predominant odoriferous gases in processes using animal raw material, such as gelatine and collagen factories and industrial wastewater treatment plants. H_2S is a corrosive, colorless, extremely toxic gas with odor of rotten egg. The California Environmental Protection Agency cites that in population terms the average odor threshold of this gas in outdoor environments is in the range of 30 to 50 ppb, for this reason it limits the concentration in the air to 30 ppb, considering the hourly average. Ammonia (NH_3) is a colorless gas with an irritating and poisonous odor if inhaled in large quantities (EPA 456, 1995). Nagata (2003) determined the olfactory limit of ammonia, evaluated in the laboratory through the "triangle odor bag" method, at 1,580 ppb. Alberta (Canada) legislation, based on the perception of odors, set the limit of 2,000 ppb for the hourly average of NH_3. The objective of the study was to identify and quantify the odor emission sources of NH_3 and H_2S/CH_4S odor gases throughout the production process of a gelatin and collagen factory. After the emission sources were evaluated, the mathematical model AERMOD was used to define the radius of odor coverage in the surroundings of the company and propose improvements or installation of new control systems in odor emission sources.

METHODS

Area of study is located in Maringá city, state of Paraná (Brazil). The measurements of the gases were carried out with the Cairpol sensors, electrochemical, automatic and continuous measurement. This equipment records the measurements in ppb (part per billion) every minute. All sources of odoriferous substances emitted from the company's production process were monitored as places around the sources too. All measurements were performed for seven days in a row. The emission sources monitored were: on the arrival of the trucks with the used raw material (bovine hides), loading of storage hopper and washing of raw materials, storage sheds, effluent treatment station (ETS) and biofilter outlet. Figure 1 shows the 28 gas monitoring points.

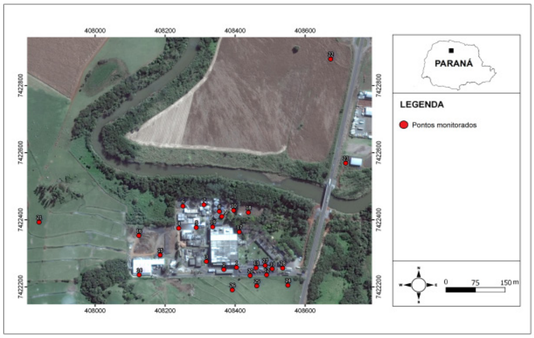

Figure 1: Monitoring points.

During the monitoring period, an anemometer was installed to record wind direction and wind speed data every 5 minutes to correlate with gas measurements. The mathematical modeling of odor dispersion was performed using the AERMOD View. The meteorological input data for the model was obtained for the period from 2013 to 2017 from the meteorological station installed in Maringá city. The terrain data was obtained from the SRTM30, land use data an online database, available at www.webgis.com. The emission data of the sources were estimated based on the gas measurements carried out in the field. A square grid of receivers with a size of 10 km x 10 km was defined in two levels of refinement. The first level had dimensions of 2 km x 2 km, spaced every 100 meters and the second level with receivers spaced every 500 m. Two scenarios were simulated: the first one contemplated the real emissions, which were estimated through field measurements. The second scenario considered reductions in H_2S/CH_4S and NH_3 emissions, with improvement in the design and operation of the biofilter and implementation of new systems for odor control in odor sources, suggesting the installation of gas scrubbers and activated carbon filters. For the biofilter, production process and storage of raw material was considered an 80% reduction of emissions. For the ETS and yard of trucks, as they are open areas, the solution for odor reduction is the use of neutralizers of ambient odor, therefore considered reduction was of 50%.

FINDINGS AND ARGUMENT

Gas monitoring

The results of the monitored maximum values of H_2S/CH_4S and NH_3 were interpolated and superimposed on the aerial image of the study area. Figure 2 shows the maximum monitored concentrations of H_2S/CH_4S. The maximum values are located throughout the ETS and close to the hopper (beginning of the raw material processing). The maximum measured concentration was 1000 ppb (maximum scale of equipment used).

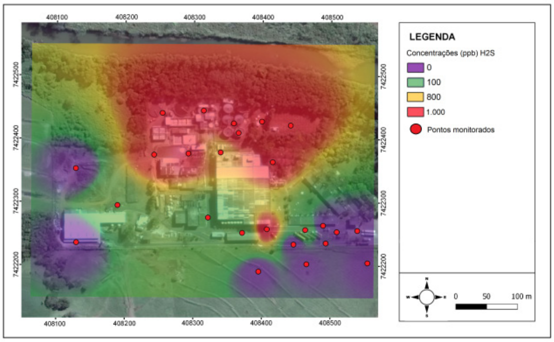

Figure 2: Results for H_2S/CH_4S

Figure 3 shows the maximum concentrations of NH_3 monitored. The maximum values are located in the unloading of the trucks and entrance of the hopper and near the biological filter. The maximum monitored value was 3,079 ppb, near the hopper.

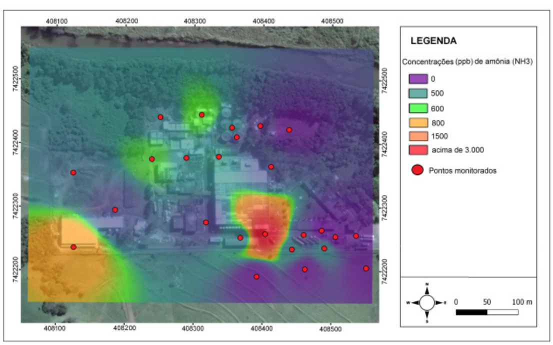

Figure 3: Results for NH_3

The results of the monitoring in the sources of emission indicating the sites of greater emission and allowed the calculation of the emission rate of the odor sources through reverse modeling, which was used as input data in the mathematical model.

MATHEMATİCAL MODELİNG

Scenario 1 - H_2S/CH_4S

The results of the maximum concentrations of H_2S/CH_4S are shown in Figure 4.

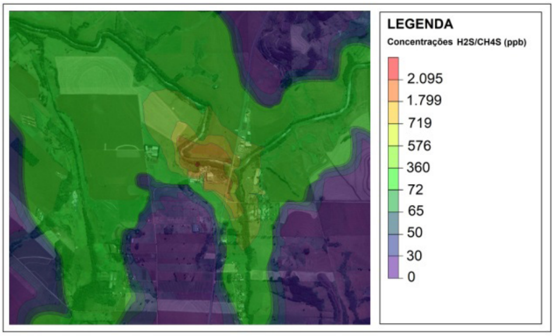

Figure 4: Results for H_2S/CH_4S – Scenario 1

The highest concentration of H_2S/CH_4S was 2,095 ppb, near the ETS. This simulation showed that in the northwest and southwest directions the concentrations could be higher than 30 ppb at distances higher than 5 km of the company, while in the other directions, the maximum distance is approximately 2.5 km.

Scenario 1 - NH_3

The results of the maximum concentrations of NH_3 are shown in Figure 5.

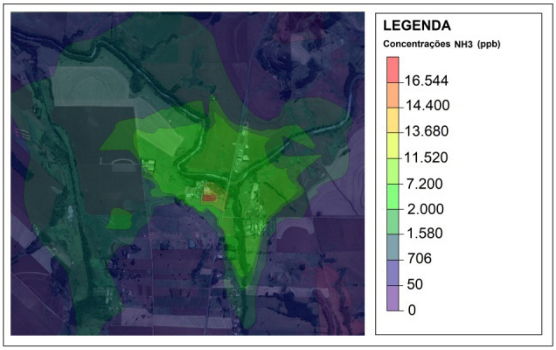

Figure 5: Results for NH_3 – Scenario 1

The odor perception range for NH_3 is concentrations above 1,580 ppb (Nakata, 2003), while Alberta (Canada) legislation sets the limit of 2,000 ppb. The highest concentration of ammonia was 16,544 ppb, close to the truck yard. In a radius of approximately 1.5 km, the concentrations were less than 1,580 ppb, whereas the concentration of 2,000 ppb was restricted to an average radius of approximately 1 km of the company.

Scenario 2 - H_2S/CH_4S

The maximum hourly concentration of H_2S/CH_4S was 934 ppb, close to ETS, indicating a reduction of 55% about scenario 1. The simulation of scenario 2 showed that in the northwest, southwest and east directions the concentrations can be higher than 30 ppb at distances higher than 4 km of the company, while in the other directions, the maximum distance in which concentrations are still higher than 30 ppb is less than 2,5 km.

Scenario 2 - NH_3

The highest ammonia concentration was 3,340 ppb, less than 20 meters from the truck yard. This concentration is 80% lower than the maximum concentration in scenario 1. Concentrations above 2,000 ppb were restricted to a distance of approximately 160 m from the company and concentrations of 1,580 ppb at a distance of about 220 m.

CONCLUSIONS

The main emission sources identified after the monitoring were: ETS, beginning of the raw material processing and storage of the raw material, besides the exit of the Biofilter. The dispersion study showed that in scenario 2 (future) there is a decrease in the NH_3 perception radius to approximately 200 meters of the company in the worst conditions of gas dispersion of the simulated period. For H_2S/CH_4S the reduction of the maximum distance of odor perception was not so significant. The main source of emission of this gas is the ETS, which was attributed a reduction of 50% of its emission, because being an open source its odor control should be by means of encapsulators, which do not allow an efficiency as high as the other control systems. The H_2S/CH_4S concentration showed a reduction of 55% from scenario 1 to 2. With the simulations carried out, it is possible to conclude that the improvements in the control of emission sources will avoid the annoyance and complaints in the neighboring community and sanctions of the environmental agency.

REFERENCES

EPA - Environmental Protection Agency. “Control and Pollution Prevention Options for Ammonia Emissions”. EPA-456/R-95-002 (1995).

Government of Alberta. Alberta Ambient Air Quality Objectives and Guidelines Summary. AEP, Air Policy, 2016, Nº. 2.

Henshaw, Paul et al. “Parameters for the assessment of odour impacts on communities”. *Atmospheric Environment* 40 (2006): 1016–1029.

Karageorgos, Petros et al. “Characterization and Dispersion Modeling of Odors from a Piggery Facility”. J. Environ. Qual 39 (2010): 2170–2178.

Nagata, Yoshio. Measurement of Odor Threshold by Triangle Odor Bag Method. Japan Ministry of the Environment, Tokyo (2003).

Schiffman, Susan S. et al. “Quantification of odors and odorants from swine operations in North Carolina”. *Agricultural and Forest Meteorology* 108 (2001): 213–240.