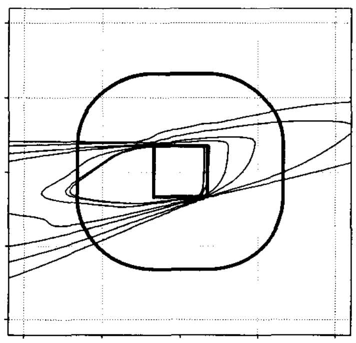
Evaluating the Effectiveness of Methyl Bromide Soil Buffer Zones in Maintaining Acute Exposures Below a Reference Air Concentration



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EXECUTIVE SUMMARY
OF REPORT EH 00-10
EVALUATING THE EFFECTIVENESS OF METHYL BROMIDE SOIL BUFFER ZONES IN MAINTAINING ACUTE EXPOSURES BELOW A REFERENCE AIR CONCENTRATION

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Background

Methyl bromide is one of the mostly widely used pesticides in California–about 15 million pounds are applied annually in the State. It is a gaseous fumigant that is used for soil fumigation to control insects, mites, rodents, nematodes, termites, weeds, and organisms that cause plant diseases. It is used prior to planting a variety of fruit, nut, vegetable, and ornamental crops.

Methyl bromide is injected into the soil with specialized application equipment a few weeks prior to planting. Tarpaulins are often used to cover the treated area and contain the gas until the fumigation is complete. Depending upon the crop, field applications may occur annually, or once every several years.

Because methyl bromide has the potential to produce harmful human health effects when inhaled, the Department of Pesticide Regulation (DPR) and the county agricultural commissioners have implemented extensive use restrictions designed to ensure that workers and the general public will not be exposed to unacceptable levels. For the purposes of DPR's regulatory program, an unacceptable level is any detected concentration that exceeds DPR's "reference concentration" of 210 parts per billion (ppb) (815 ug/m^3). The term reference concentration refers to the exposure level that DPR believes represents an acceptable level of risk. Reference concentrations are typically 100 times lower than doses that do not cause adverse effects—or the no-observed-effect level [NOEL]—identified in animal studies. The 100-fold factor accounts for variation in sensitivity between individuals and assumes that people are more sensitive than experimental animals to the effects of methyl bromide.

A key approach used to implement the methyl bromide use restrictions is the establishment of a "buffer zone" around a fumigated field. The buffer zone is an area that surrounds a fumigated field. Within this area, activities are restricted to protect human health and safety.

Purpose:

This study was conducted to evaluate the effectiveness of the methyl bromide buffer zones established by DPR in 2001. To calculate the size of buffer zones, DPR adapted the U.S. EPA Industrial Source Complex-Short Term 3 (ISCST3) model, commonly used for predicting emissions of industrial air pollution. The ISCST3 model predicts air concentrations based on the magnitude of emissions during a period of time (flux), weather conditions at the time of emission (e.g., wind speed, wind direction, atmospheric stability), and terrain over the downwind area (elevation, urban or rural geography). DPR inputted into the ISCST3 model the following data: 1) a flux value (an estimate of the amount of methyl bromide gas rising from a field over time following a fumigation); 2) the number of acres treated; 3) a standardized set of weather conditions. The calculation resulted in a prescribed buffer zone for specific combinations of field sizes and flux magnitudes. Prescribed buffer zone sizes range from 30 to 3400 feet measured from the edge of the fumigated field, depending on field size and flux (which is related to the amount of methyl bromide used and the method of application).

The intent of the buffer zone is to prevent unacceptable exposures under a wide range of weather conditions. The prescribed buffer zone must take into account these factors by establishing a distance that is protective under different scenarios. For instance, the amount of methyl bromide gas rising from a field declines from time of application, and but the rate of decline can be influenced by such factors as application depth, tarpaulin permeability, and soil moisture, texture, and density. In addition, identical applications may show variations at different times of the year due to differences in meteorological conditions. To calculate buffer zone sizes adequate for most agricultural applications, varying field sizes and methyl bromide flux rates were inputted in all computer simulations with a standard meteorological condition, which approached, but did not represent the worst-case situation.

Within this current study, DPR took two approaches to test the effectiveness of the prescribed methyl bromide buffer zones around a treated field. One method evaluated how often the reference concentration of 210 ppb was exceeded at the outer edge of the prescribed buffer zone. A second method evaluated the effectiveness of the buffer zone distances in maintaining acute exposures below the 210 ppb level. This report also responds to comments made by a National Academy of Sciences panel during its peer review of DPR's methyl bromide risk assessment.

Study Methods

Meteorological data were obtained from the California Irrigation Management Information System weather station network for the five counties with the highest methyl bromide soil application use as documented by California's pesticide use report. The data were screened using U.S. EPA methodology to produce four data sets, each consisting of five years of daily meteorological data for Fresno, Merced, Monterey, and Ventura counties. When combined, the entire data set provided 20 years of daily meteorological data.

Model simulations–the generation of hypothetical data values based upon specific flux, acreage, and historical weather conditions–consisted of daily (24 hour) simulations using the ISCST3 version 99155 model. Simulations covered five field sizes (1, 10, 20, 30 and 40 acres) and five flux values (30, 80, 130, 180 and 225 pounds per acre-day [lbs/acre-day]) to yield 25 combinations of acreage and flux. For each of the 25 acreage/flux combinations, 20 years of daily meteorological data were applied to generate 7,166 data points. Each day of calculation produced either distances to the 210 ppb (815 ug/m^3) reference concentration or air concentrations calculated at the buffer zone distance.

Two cumulative frequency distributions were calculated for distances and air concentrations. One was the cumulative frequency distribution for the maximum air concentration or maximum distance to the reference concentration for each of the field size, flux, and meteorologically defined day combination. This represented a worst-case scenario at each of the simulated field size, flux, and meteorologically defined day combinations.

A second, more comprehensive cumulative frequency distribution was calculated for all distances to the reference concentration, or all concentrations at the buffer zone distance at each of the simulated field size, flux, and meteorologically defined day combinations using all directional vectors surrounding the field size. In other words, these comprehensive cumulative frequency distributions are representative of every direction around a 360 degree arc surrounding every field size. They include values representing all wind directions during the meteorological conditions defining that specific day.

Results

The methyl bromide buffer zones were effective in capturing air concentrations greater than the reference concentration of 210 ppb (815 ug/m^3) for fields ranging from 1 to 40 acres in size using the tested range of flux rates. The level of effectiveness ranged from 100% to 89.2% under the worst case maximum daily distance scenario, and from 100% to 98.6% when the cumulative frequency distribution for distances radiating in all directions from a field was evaluated. The lowest efficiencies were observed in the 40-acre field x 30 lbs/acre-day combination under both testing scenarios when the efficiencies were 89.2% for maximum daily distance and 98.6% for the all directions case, respectively.

The second method of evaluating the effectiveness of the methyl bromide buffer zones using cumulative frequency distributions of the maximum air concentrations at the buffer zones, and air concentrations at the buffer zone distances radiating in all directions from the field produced identical results. In the context of evaluating buffer zone adequacy, air concentration and distance are surrogates for each other due to the unique ISCST3 solution for any given daily meteorological parameter set.

This exercise provided an independent quantitative validation of the prescribed methyl bromide buffer zones, developed using the DPR standard meteorological condition. Buffer zones were effective in including at least 89.2% of air concentrations exceeding 210 ppb (815 ug/m^3) under a worst case scenario where only maximum value of distance and/or air concentrations exceeding the reference concentration when all distances and/or air concentrations were considered.

Outliers

Outlier values most often resulted from meteorological data that were acquired on days that were colder, winter days with stable conditions and lower wind speeds and a higher number of calm hours.

Verification of Model Results

The program-estimated daily required buffer zones closely matched manually derived required buffer zones. Similarly, the comparison between the maximum concentration along the buffer zone and manually derived values was also very close.

Conclusion

This study indicates that the proposed buffer zones achieve the desired result–protection of the public from exposure to unacceptable levels of methyl bromide for most applications. In a small number of applications, the 100-fold safety margin would be reduced. However, it should be noted that although the four counties whose meteorology was used in this study are among the areas of heaviest methyl bromide use, a significant portion of the methyl bromide use in the state (62 percent) occurs in the State's other 54 counties. The four counties used in this study (two coastal and two inland valley) represent varying meteorological conditions, but it is possible that they may not accurately represent statewide conditions and that regional variations may produce differing results.

Another reasonable question is whether there are meteorological conditions that are not captured by the methodology in this study that could lead to high methyl bromide concentrations. For instance, calm meteorological conditions are not simulated by the ISCST3 model (or its replacement model, AERMOD), and yet calm conditions could conceivably lead to high methyl bromide concentrations.