HEALTH HAZARD EVALUATION REPORT

HETA 94-0331-2535
CACKLE CORNERS
VALLIANT, OKLAHOMA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from an employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

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SUMMARY

Environmental sampling was conducted at a chicken farm in response to a request for a health hazard evaluation (HHE) of the risk for inhalation exposure to organic arsenic. The request resulted from concern that the addition of 3-Nitro® (active ingredient: roxarsone [3-nitro-4-hydroxyphenylarsonic acid]) to poultry feed exposed poultry growers and catchers to organic arsenic compounds. Because roxarsone is a slightly soluble organic pentavalent compound, it is predicted to be of relatively low toxicity. But little is actually known about the acute or chronic toxicity of any organic arsenicals. The only exposure limit for organic arsenic compounds is the OSHA PEL of 500 micrograms (µg) per cubic meter of air, measured as arsenic.

Area air sampling was conducted at three to five different locations in each of the four chicken houses at Cackle Corners during chicken catching operations. Seventeen area air samples, four litter samples, four rafter dust samples, two compost samples, three feed samples (starter, middle, and final), and a roxarsone sample were analyzed for arsenic and 27 other elements by NIOSH method 7300. Arsenic was not detected in any of the 17 area air samples; the analytical limit of detection (LOD) was 1 µg per sample. Each litter sample and one rafter dust sample contained 20 µg of arsenic per gram of material (µg/gm). Because this value is between the analytical LOD (8 µg/gm) and limit of quantitation (25 µg/gm), it is considered a trace concentration. Arsenic was not detected in three rafter dust samples. Compost samples contained 26 µg/gm and 51 µg/gm of arsenic. Starter feed contained 25 µg/gm, middle feed contained 30 µg/gm, and no arsenic was detected in the final feed. The roxarsone sample contained approximately 67,000 µg/gm of arsenic, or 6.7% by weight.

The findings of this HHE suggest that there is essentially no health risk associated with inhalation exposures to organic arsenic from the addition of small amounts of roxarsone to poultry feed. However, air concentrations of organic dust, microorganisms, bacterial endotoxin, and ammonia measured in chicken houses by other researchers suggest that poultry workers are at risk for experiencing adverse respiratory health effects. A substantial body of evidence in the occupational health literature confirms that poultry workers are at risk for respiratory disease. While wearing respirators is the least desirable method for reducing workers' exposures, respirator use is currently the most feasible method available for protecting the health of poultry workers. Recommendations are provided for selecting respirators for use by poultry growers.

Keywords: SIC 0251 (chicken farms), agriculture, chickens, organic arsenic, poultry growers, roxarsone (3-nitro-4-hydroxyphenylarsonic acid).

INTRODUCTION

An industrial hygienist from the National Institute for Occupational Safety and Health (NIOSH) conducted environmental sampling at Cackle Corners in Valliant, Oklahoma, on July 20, 1995. The site visit at this chicken farm was in response to a request for a health hazard evaluation of the risk for inhalation exposure to organic arsenic. The request resulted from a concern that the addition of 3-Nitro® (active ingredient: roxarsone [3-nitro-4-hydroxyphenylarsonic acid]) to poultry feed would expose poultry growers and catchers to organic arsenic compounds. The potential for exposure occurs while working with not only poultry feed but also compost and chicken house litter containing organic arsenic excreted by the birds.

Each of the four chicken houses at Cackle Corners was a full-span, half-side structure with an area of 12,000 square feet (40 feet by 300 feet). Each house had cup drinkers that ran the entire length of the house and sheltered approximately 17,000 chickens on the day of sampling. All of the 68,000 chickens caught that day were 6 weeks old and were the first flocks in the houses since the litter was renewed.

EVALUATION CRITERIA

General Guidelines

To assess the hazards posed by workplace exposures, NIOSH investigators use a variety of environmental evaluation criteria. These criteria suggest exposure levels to which most workers may be exposed for a working lifetime without experiencing adverse health effects. However, because of wide variation in individual susceptibility, some workers may experience occupational illness even if exposures are maintained below these limits. The evaluation criteria do not take into account individual hypersensitivity, pre-existing medical conditions, or possible interactions with other workplace agents, medications being taken by the worker, or environmental conditions. Evaluation criteria typically change when new information on the toxic effects of an agent become available.

The primary sources of evaluation criteria for the workplace are NIOSH criteria documents and recommended exposure limits (RELs),[(1)] the American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit values (TLVs),[(2)] and the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs).[(3)] These values are usually based on a time-weighted average (TWA) exposure, which refers to the average airborne concentration of a substance over an entire 8- to 10-hour workday. Concentrations are usually expressed in parts per million (ppm), milligrams per cubic meter (mg/m^3), or micrograms per cubic meter ($\mu g/m^3$). In addition, some substances have only a ceiling limit, a concentration that should not be exceeded during any part of a workday.

Other substances have a short-term exposure limit (STEL) to supplement a TWA limit where there are recognized toxic effects from short-term exposures. A STEL is a 15-minute TWA

concentration which should not be exceeded at any time during a workday even if the 8-hour TWA is less than the exposure limit. The ACGIH recommendation for a substance without a STEL is that "excursions in worker exposure levels may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a workday, and under no circumstances should they exceed 5 times the TLV-TWA, provided that the TLV-TWA is not exceeded."[(2)] The basic concept is that excursions above a substance's 8-hour TWA exposure limit should be maintained within reasonable limits in well-controlled processes. Additionally, some chemicals have a skin notation to indicate that the substance may be absorbed through direct contact of the material with the skin and mucous membranes.

NIOSH RELs are based primarily on the prevention of occupational disease. In contrast, OSHA PELs and other OSHA standards are required to take into account the economic feasibility of reducing exposures in affected industries, public notice and comment, and judicial review. In evaluating worker exposure levels and NIOSH recommendations for reducing exposures, it should be noted that employers are legally required to meet OSHA standards. An additional complication is that a Court of Appeals decision vacated the OSHA 1989 Air Contaminants Standard in *AFL-CIO v OSHA*, 965F.2d 962 (11th cir., 1992); OSHA now enforces the previous 1971 standards.[(3)] However, some states which have OSHA-approved state plans will continue to enforce the more protective 1989 OSHA PELs. NIOSH encourages employers to use the 1989 OSHA PELs or the NIOSH RELs, whichever are lower.

Arsenic

Arsenic is a transition element or metalloid. This classification reflects the fact that arsenic commonly forms complexes with metals, but it also reacts readily to form covalent bonds with carbon, hydrogen, and oxygen. Far more organic compounds of arsenic have been made than of any other trace element. Arsenic may exist in three different oxidation or valence states, namely, the metalloid (0 oxidation state), arsenite (trivalent or +3 oxidation state), and arsenate (pentavalent or +5 oxidation state). Different arsenic-containing compounds vary substantially in their toxicity to mammals. Arsine gas is clearly the most toxic, followed in order of generally decreasing toxicity by inorganic trivalent compounds, organic trivalent compounds, inorganic pentavalent compounds, organic pentavalent compounds, and elemental arsenic. Toxicity also depends on other factors such as physical state, particle size, the rate of absorption into cells, the rate of elimination, the presence of impurities, and the nature of chemical substitutes in the compound.[(4)]

Roxarsone is an organic pentavalent compound and, according to its material safety data sheet, is slightly soluble in cold water.[(5)] As with other metallic compounds, the toxicities, especially the acute toxicities, of arsenic compounds are related to their solubility in water.[(6)] Therefore, since roxarsone is a slightly soluble organic pentavalent compound, it would be predicted to be of relatively low toxicity. Unfortunately, little is actually known about the acute or chronic toxicity of any organic arsenicals.[(7)] The only occupational exposure limit for organic arsenic compounds is the OSHA PEL of 500 $\mu g/m^3$ of sampled air, measured as arsenic.[(8)] This exposure limit was

adopted by OSHA 25 years ago from a previous threshold limit value for arsenic established by ACGIH. In 1991, unlike OSHA, ACGIH no longer based its exposure limits on whether an arsenic compound was inorganic or organic in nature; a single TLV was established for arsenic and soluble compounds.[6] In 1993, ACGIH adopted its current TLV, which applies to elemental and inorganic arsenic, and made no reference to a TLV applicable for exposure to organic arsenic compounds.[2]

ENVIRONMENTAL SAMPLING METHODS

Area air sampling was conducted at three to five different locations in each of the four chicken houses at Cackle Corners during chicken catching operations. Two air samples were collected at each location, and a total of 17 pairs of air samples were submitted for laboratory analysis. Each air sampling train consisted of an air sampling pump operating at 1.5 liters per minute that was connected by flexible tubing to a 37-mm cassette. One of the cassettes at each sampling location contained a 0.8-micrometer (µm) pore-size, cellulose ester membrane filter. Each of these filters was analyzed for arsenic and 27 other elements by NIOSH method 7300.[9] Each filter was analyzed for the following 28 elements:

Aluminum	Cobalt	Molybdenum	Tellurium
Arsenic	Copper	Nickel	Thallium
Barium	Iron	Phosphorus	Titanium
Beryllium	Lead	Platinum	Vanadium
Cadmium	Lithium	Selenium	Yttrium
Calcium	Magnesium	Silver	Zinc
Chromium	Manganese	Sodium	Zirconium

The second cassette at each sampling location contained a 5-µm pore size, polyvinyl chloride filter. Each of these filters was analyzed for total particulate by NIOSH method 0500.[10] Two sampling trains were used at each sampling location in case there was a need to estimate the percentage of arsenic in aerosolized dust.

Fourteen bulk samples were also collected and analyzed for arsenic and 27 other elements by NIOSH method 7300.[9] These samples consisted of four litter samples, four rafter dust samples, two compost samples, and three feed samples (starter, middle, and final). Roxarsone is added to starter and middle feeds by Tyson Foods, the poultry processing company for whom the chickens are grown. Chickens are fed roxarsone-free feed for at least five days before they are caught and transported to the company's processing plant. A roxarsone sample, which was provided to the NIOSH researcher by an employee of the processing company, was also analyzed for arsenic.

ENVIRONMENTAL SAMPLING RESULTS

Arsenic was not detected in any of the 17 area air samples; the analytical limit of detection (LOD) was 1 µg per sample. Based on an average air sampling volume of 170 liters, the minimum detectable air concentration of arsenic was 6 $\mu g/m^3$ (range: 3 $\mu g/m^3$ to 10 $\mu g/m^3$). Fifteen of the other elements were also reported as not detected on the filters of the area air samples. Of the remaining 12 elements, only trace amounts (less than 10 µg/sample) were reported. The amount of dust collected on the 17 particulate filters ranged from 300 µg to 530 µg.

Each of the four litter samples and the rafter sample from house number one contained 20 µg/gram (gm) (equivalent to 20 ppm) of arsenic. Because this value is between the analytical method's limit of detection (8 µg/gm) and limit of quantitation (25 µg/gm), it should be considered a trace concentration. Arsenic was not detected in the rafter samples from the other three chicken houses. The two compost samples contained 26 µg/gm and 51 µg/gm of arsenic. The starter feed sample contained 25 µg/gm of arsenic, the middle feed contained 30 µg/gm, and none was detected in the final feed. The roxarsone sample contained approximately 67,000 µg/gm of arsenic, or 6.7% by weight.

Overall, the concentrations of the elements in all of the bulk samples were low, and only calcium and phosphorus were found to comprise greater than 1 percent of any one bulk sample. The highest amount of calcium was 3.7 percent in a compost sample, and the highest amount of phosphorus was 2.8 percent in the same compost sample.

DISCUSSION AND CONCLUSION

Nearly 50 years ago, the addition of small amounts of 3-nitro-4-hydroxyphenylarsonic acid or roxarsone was reported to significantly stimulate the growth of poultry.[11] Today, the amount of roxarsone added to poultry feed is essentially the same as was originally recommended in 1948, 45 gm/ton, which comprises about 0.005% of the feed. The trace amount of arsenic measured in the litter samples of this study (20 µg/gm) are similar to the results reported in a published article.[12] In that study, litter samples were collected from chicken houses on the Eastern Shore of Maryland. The concentration of arsenic measured in litter samples collected from eight different chicken houses in which five or more flocks had been raised and fed roxarsone ranged from 3 to 60 µg/gm. Data from an unpublished 1995 EPA report show that 13 litter samples, which were also collected from chicken houses on the Eastern Shore of Maryland, contained arsenic concentrations ranging from less than 2.4 µg/gm (5 samples) to 40 µg/gm.[13] Arsenic concentrations reported for a 3-year old manure sample and a compost sample were 60 µg/gm and 45 µg/gm, respectively.

Eight-hour time-weighted average concentrations of airborne dust as high as 35 mg/m^3 have been measured on poultry growers while working in their chicken houses.[14] If this airborne dust concentration was assumed to contain 60 µg/gm of arsenic, then an arsenic exposure of 2 µg/m^3 would result. An arsenic exposure of 2 µg/m^3 is very much less than the OSHA PEL of 500 µg/m^3. Consequently, a conclusion can be made that there is essentially no health risk associated with inhalation exposures to organic arsenic from the addition of small amounts of roxarsone to poultry feed.

RECOMMENDATIONS

While airborne arsenic concentrations present during work in a chicken house are probably so low that they can be considered essentially risk-free, working in a chicken house cannot be considered risk-free for other reasons. Very few jobs are associated with dustier working conditions than those found in a chicken house. Air concentrations of organic dust, microorganisms, bacterial endotoxin, and ammonia measured during poultry-growing tasks and chicken catching suggest that the poultry workers who do these jobs are at risk for experiencing adverse respiratory health effects.[14-16] A substantial body of evidence exists in the occupational health literature documenting that poultry workers are at risk for developing respiratory disease, and consequently, that there is a need to protect the health of poultry workers. Acute and chronic respiratory symptoms reported by poultry workers and the results of pulmonary function testing suggest that exposures to airborne contaminants by poultry workers can result in respiratory dysfunction.[17-19]

The best way to protect workers from exposure to airborne contaminants is with effective engineering controls that capture potential contaminants at their source before they can become airborne. In most industrial environments, airborne contaminants can be reduced to safe levels at their source by the installation of effective engineering control measures. Wearing respirators is the least desirable method for reducing workers' exposures to airborne contaminants, and the use of respirators is recommended only when engineering controls are not feasible, or while they are being installed or repaired. The general ventilation systems in poultry houses are not primarily intended to reduce the exposures of those who work in the houses. Ventilation systems designed especially for this purpose would likely be economically and mechanically impractical.[20] Consequently, wearing respirators is currently the most feasible method available for protecting the health of poultry workers.

To ensure that respirator wearers are adequately protected, respirators must be used in accordance with a complete respiratory protection program. One of the most important aspects of a respiratory protection progam is respirator selection. Because not all respirators provide the same level of protection, assigned protection factors are used during the selection process to help distinguish between the various classes of respiratory protection. The assigned protection factors listed in the *NIOSH Respirator Decision Logic* for protection against particulate exposures like poultry dust range from 5 to 10,000.[20-22] Quarter mask respirators and most disposable respirators are representatives of the low end of the range, and self-contained breathing apparatuses operated in pressure-demand modes represent the high end.
A full facepiece respirator with high-efficiency filters has been recommended for poultry workers

based upon the results of air sampling conducted during chicken catching.[14] This class of respiratory protection has an assigned protection factor of 50.[20-22] If there is also a need to reduce ammonia exposures of poultry workers, most respirator manufacturers sell combination or "piggyback" cartridges that filter ammonia and particulates. More expensive powered air-purifying respirators with tight-fitting facepieces have also been recommended for protecting agricultural workers.[22] This class of respiratory protection has an assigned protection factor of 50 as well, but these devices have the advantage that filtered air is constantly delivered to the wearer's facepiece resulting in less breathing resistance. Hooded powered air-purifying respirators are also available for workers with beards.

Repeated exposures of the eyes to poultry dust increase the risk for eye injury and disease. Most dust particles entering a person's eyes will be washed out by tears, but some particles can be retained in the eye, particularly within the margin of the upper eyelid. These dust particles can become embedded in the surface of the cornea or sclera, where they cause irritation followed by reddening of the surface and, if not removed, may produce an ulcer and infection.[23] Respirators with full facepieces and those with hoods have the built-in benefit of also providing eye protection. Poultry workers who wear half-mask respirators should also wear eyecup goggles to protect their eyes.

The level of respiratory protection needed for a particular situation can vary depending on a variety of factors. For example, airborne dust and ammonia concentrations in chicken houses are affected by the age of the birds, the age of the litter, drinker type, and the position of the side curtains. Less-protective respirators than full facepiece and powered air-purifying respirators may be adequate for some work situations. However, downgrading the level of protection, such as to half-mask or to disposable respirators, is recommended only after sufficient environmental and medical evidence is collected to clearly show that the use of a respirator with less protective capability will reduce exposures to safe levels.[22]

Over the last few years, the expense of establishing and maintaining a complete respirator program has decreased primarily due to the reduced cost of respirator fit testing equipment. Because of technical advances, the cost of quantitative fit testing equipment has declined from several thousand dollars to about $4,000. However, this amount is still too costly for individual poultry farmers. Therefore, poultry processing companies that have developed a respiratory protection program for their employees should invite their contract growers and catchers to participate in the program as well.

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