Topical Session D: Pharmaceuticals

Environmental Considerations for Animal Pharmaceuticals

Charles E. Eirkson III[1]

Animal drugs and feed additives are routinely used in high production agricultural animals. They can be used for therapeutic, production, or nutritional purposes and be administered for a short or extended period. Some drugs and additives may be completely metabolized to inactive components but some are excreted as active metabolites or parent substance. All of these residues are contained in the animal waste from cattle, swine, poultry, and fish facilities. Runoff and leaching from feedlots or aquaculture facilities can carry the remaining substances into surface and ground water. Manure and litter also are used or disposed of on land where it is incorporated into soil. Runoff and leaching to surface and ground water from land applications could also occur. The U.S. Food and Drug Administration, Center for Veterinary Medicine has conducted environmental reviews of many animal drug products. The reviews include information (for example, aqueous solubility and soil sorption) that can be used to determine the potential for a drug to enter surface or ground water. Additional information (for example, acute invertebrate toxicity and plant toxicity) often is collected that can be used to determine potential environmental toxicity. These data are used in environmental-risk assessments to estimate environmental impacts for the animal drug products.

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[1]U.S. Food and Drug Administration, Center for Veterinary Medicine, 7500 Standish Place, Rockville, MD 20855 (ceirkson@cvm.fda.gov)

Occurrence of Antibiotics in Liquid Waste at Confined Animal Feeding Operations and in Surface and Ground Water

Michael T. Meyer[1], J.E. Bumgarner[2], J.V. Daughtridge[3], Dana Kolpin[4], E.M. Thurman[5], and K.A Hostetler[6]

Radioimmunoassay and immunoassay tests were used to screen for five classes of antibiotics in liquid waste from confined animal feeding operations and in surface and ground water. Approximately one-half of the fifty million pounds of antibiotics produced annually in the United States is for agriculture, with the majority used as feed additives for growth promotion. One or more classes of antibiotics were detected in the liquid waste collected from eight hog lagoons. Tetracycline was the most frequently detected class of antibiotics followed by the sulfonamides, beta-lactams, and macrolides. Estimated concentrations of individual antibiotic screens of samples from the hog-lagoon samples ranged from less than 1 to more than 700 micrograms per liter (μg/L). In ground water, the tetracycline class of antibiotics was detected in a well sample collected near a hog lagoon, and the sulfonamide class was detected in another well sample near a different hog lagoon. The tetracycline class of antibiotics was tentatively detected in 1 of 13 surface-water samples at a concentration less than 1 μg/L. The presence of chlortetracycline in the liquid waste and the surface-water samples that responded positively to the tetracycline radioimmunoassay was confirmed on a subset of samples by using liquid chromatography/mass spectrometry with on-line, solid-phase extraction. The data from this study indicate that antibiotics are present in waste generated at confined animal feeding operations and may be available for transport into surface and ground water. These data indicate that methods with lower detection levels may be needed to study the occurrence of antibiotics in surface and ground water.

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[1]U.S. Geological Survey, 3916 Sunset Ridge Road, Raleigh, NC 27607 (mmeyer@usgs.gov)

[2]U.S. Environmental Protection Agency, MD-44, Research Triangle Park, NC 27711 (bumgarner.joseph@epa.gov)

[3]U.S. Environmental Protection Agency, MD-44, Research Triangle Park, NC 27711 (daughtridge.joel@epa.gov)

[4]U.S. Geological Survey, P.O. Box 1230, Iowa City, IA 52244 (dwkolpin@usgs.gov)

[5]U.S. Geological Survey, 4821 Quail Crest Place, Lawrence, KS 66049 (ethurman@usgs.gov)

[6]U.S. Geological Survey, 4821 Quail Crest Place, Lawrence, KS 66049 (khostet@usgs.gov)

Pharm-Chemical Contamination: A Reconnaissance for Antibiotics in Iowa Streams, 1999

Dana Kolpin[1], David Riley[2], Michael T. Meyer[3], Peter Weyer[4], and E.M. Thurman[5]

About 90 percent of the roughly 2.5 million kilograms of antibiotics used for livestock production in the United States each year are given as growth-promoting and prophylactic agents rather than to treat active infections. These subtherapeutic levels of antibiotics are one of the factors that have allowed the confinement of animals in large production facilities, thereby lowering the costs of animal care. There has been increasing public concern, however, that this widespread antibiotic use may lead to contamination of the Nation's ground and surface waters -- increasing the potential for the creation of antibiotic-resistant bacteria that could pose a risk to human health.

Currently in the United States, there is little known about the occurrence and fate of antibiotics in the hydrologic system. A study was conducted during the spring of 1999 to provide baseline data on the occurrence of antibiotics in streams. A network of 30 streams was selected across Iowa representing basins containing low to intense hog production. Water samples were collected from these streams during the first runoff event following snowmelt (a time when there is an increased likelihood of antibiotic transport to streams). Water samples will be analyzed for a broad spectrum of antibiotics (20-30 compounds) using liquid-chromatography/mass-spectrometry technology. Reporting limits for these compounds are estimated to be between 0.05 and 0.2 microgram per liter.

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[1]U.S. Geological Survey, P.O. Box 1230, Iowa City, IA 52244 (dwkolpin@usgs.gov)

[2]University of Iowa, Center for Health Effects of Environmental Contamination, 100 Oakdale Campus #N202 OH, Iowa City, IA 52242-5000 (david-riley@viowa.edu)

[3]U.S. Geological Survey, 3916 Sunset Ridge Road, Raleigh, NC 27607 (mmeyer@usgs.gov)

[4]University of Iowa, Center for Health Effects of Environmental Contamination, 100 Oakdale Campus #N202 OH, Iowa City, IA 52242-5000 (peter-weyer@viowa.edu)

[5]U.S. Geological Survey, 4821 Quail Crest Place, Lawrence, KS 66049 (ethurman@usgs.gov)

Analysis of Tetracycline and Sulfamethazine Antibiotics in Ground Water and Animal-Feedlot Wastewater by High-Performance Liquid Chromatography/Mass Spectrometry Using Positive-Ion Electrospray

E.M. Thurman[1] and K.A. Hostetler[2]

Two classes of antibiotics used in animal feed (tetracyclines and sulfamethazines) are analyzed from ground-water and wastewater samples by high-performance liquid chromatography/mass spectrometry (HPLC/MS) using positive-ion electrospray with a detection limit of 0.2 microgram per liter (μg/L). The method consists of filtering 40 milliliters (mL) of water sample through a 0.45-micron glass-fiber filter followed by acidification with phosphoric acid to pH 2. The sample is passed through a solid-phase extraction (SPE) cartridge (ENV+, polymeric resin) and dried under vacuum. The cartridge then is eluted with 4N NH_4OH in methanol, vortexed, and filtered. SPE recovery is approximately 80%. The eluate then is injected into the HPLC/MS system, which is running a methanol/water gradient from 10 to 80% methanol. The addition of the ammonium hydroxide is critical in the hydrolysis of the various epimers of chlortetracycline. The hydrolysis occurs rapidly, giving one chromatographic peak rather than the six epimeric forms of chlortetracycline. The ions monitored by selected-ion monitoring are 479, 481, and 501 (a sodium adduct) for chlortetracycline and 279, 281, and 301 (sodium adduct) for sulfamethazine. Internal standards are used for quantitation, including tetracycline for chlortetracycline and $^{13}C_6$ sulfamethazine for sulfamethazine. Analysis of several ground-water samples collected near waste lagoons and wastewater-lagoon samples show that the antibiotics are detected readily at microgram-per-liter concentrations.

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[1]U.S. Geological Survey, 4821 Quail Crest Place, Lawrence, KS 66049 (ethurman@usgs.gov)
[2]U.S. Geological Survey, 4821 Quail Crest Place, Lawrence, KS 66049 (khostet@usgs.gov)

A Reconnaissance for Hormone Compounds in the Surface Waters of the United States

Larry B. Barber[1], Greg K. Brown[2], Dana Kolpin[3], Jeffery H. Writer[4], and Steven D. Zaugg[5]

The occurrence of hormone compounds, such as 17-b-estradiol and testosterone in surface waters, has become a topic of concern because of potential adverse effects including disruption of the endocrine system of aquatic organisms. Sources of hormones to natural waters include disposal of effluents from municipal sewage-treatment plants and animal feeding operations. To evaluate the presence of hormone compounds in surface waters across the United States, a reconnaissance survey was conducted in spring 1999. Samples were collected from 24 streams in 19 States (Arkansas, Colorado, Georgia, Iowa, Illinois, Louisiana, Maryland, Minnesota, Michigan, Missouri, North Carolina, Nebraska, Ohio, Oklahoma, Pennsylvania, Texas, Utah, Washington, and Wisconsin). This survey included 14 streams from basins with intense production of hogs (2), poultry (6), dairy cattle (2), beef cattle (2), and mixed-animal production (2). In addition, streams from nine urban basins (including Denver, Dallas, Minneapolis, and Salt Lake City) and one mixed basin (Mississippi River near St. Francisville, Louisiana) were sampled. The samples were analyzed using continuous liquid-liquid extraction with selected ion monitoring gas chromatography/mass spectrometry (SIM GC/MS). Wastewater contaminants such as nonylphenol and triclosan were detected in 50% of the samples at part per billion concentrations. Specific analysis of steroid hormones using derivatization SIM GC/MS analysis indicated the presence of androgens and estrogens at part per trillion concentrations.

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[1]U.S. Geological Survey, Box 25046, MS 408, Denver Federal Center, Denver, CO 80225-0046 (lbbarber@usgs.gov)

[2]U.S. Geological Survey, Box 25046, MS 408, Denver Federal Center, Denver, CO 80225-0046 (gkbrown@usgs.gov)

[3]U.S. Geological Survey, P.O. Box 1230, Iowa City, IA 52244 (dwkolpin@usgs.gov)

[4]Centaurus High School, 10300 E South Boulder Rd., Lafayette, CO, 80026

[5]U.S. Geological Survey, Box 25046, MS 407, Denver, CO 80225-0046 (sdzaugg@usgs.gov)