Cooperative Extension
Colorado State University

DECEMBER 2004
VOLUME 24
ISSUE 3

INSIDE THIS ISSUE

Colorado State University Cooperative Extension

Putting Knowledge to Work

FROM THE GROUND UP

Agronomy News

Antibiotics in the Environment

Antibiotics have recently been detected in surface water bodies around the country.

Low levels of antibiotics have recently been detected in surface water bodies around the country (Kolpin et al., 2002). In Colorado in particular, Yang and Carlson (2003) have reported tetracycline and sulfonamide levels in the Poudre River and have concluded that there are both urban and agricultural influences on the occurrence of antibiotics in the river.

There are several potential sources of antibiotics including human and animal uses that could be transmitted to a water body through wastewater treatment plants, feed mills, lagoons, or runoff from livestock operations or manured fields. Ken Carlson's group at Colorado State University recently sampled seven dairy lagoons and seven dairy manure stockpiles and analyzed them for several antibiotic classes. The lagoon samples ranged from non-detectable (ND) levels to 17 parts per billion tetracyclines, ND

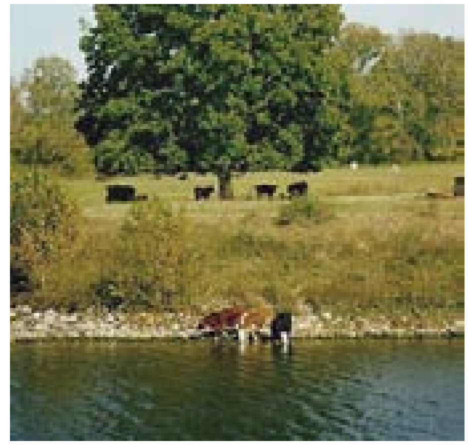
Antibiotics in the Environment (continued)

to 17 parts per billion sulfonamides, and 19 parts per billion for the macrolides. The solid manure samples also ranged from non-detectable levels to 5130 parts per billion tetracyclines, ND to 46 parts per billion of sulfonamides, and ND to 5 parts per billion macrolides.

Antibiotics have been found in water bodies and in manure sources, but the question remains: are antibiotics transported from livestock manure and wastewater storage areas to water bodies? We have begun transport studies to evaluate runoff and leaching of antibiotics from manured fields, but many unanswered questions remain. Carlson's most recent work documents monensin in the agricultural areas of the Poudre River. This is particularly important because monensin has no human use; therefore, it serves as a marker illustrating that the cattle industry is a source of antibiotic contamination in this water body.

In addition to identifying contamination sources, we need to know whether the levels measured in water bodies are high enough to have negative environmental impacts. In general, most measured concentrations have been well below (an order of magnitude lower) the levels that have been shown to be toxic to standard testing organisms (Boxall et al., 2003). There are exceptions to this general observation including ivermectin and doramectin in manure and monensin in soil (Boxall et al., 2003). Degradation products and interactions among compounds have not been adequately evaluated and could result in synergistic toxic effects.

In addition to direct toxicity effects, antibiotics in the environment could lead to the development of antibiotic resistance, a critical concern as it relates to the efficacy of antibiotics in the treatment of human disease. This is not a new concern; in 1989, the National Academy of Sciences concluded that the use of antibiotics in animal feeding operations was seriously undermining the ability of



antibiotics to protect human health. The World Health Organization called for a ban on routine feeding of antibiotics to livestock in 1997. Amy Pruden's research group at Colorado State University is evaluating the presence of antibiotic resistance genes in the sediments of the Poudre River in order to address this concern.

Other impacts that have not yet been fully evaluated include potential effects on soil fauna (such as earthworms) and microbial populations and processes. Preliminary data show that antibiotics may inhibit the mineralization of manure nutrients in soil (Boxall et al., 2003). There are also potential (but unknown) impacts on crop growth, yields, and quality.

If livestock operations are indeed a source of antibiotic contamination of water bodies, then it will be important to know what manure management decisions can be made to hasten the degradation of antibiotics and limit their potential negative impacts. We are currently evaluating treatments such as composting (Amy Pruden), lagoon aeration (Ken Carlson), and

continued on page 3

FROM THE GROUND UP

Agronomy News is a monthly publication of Cooperative Extension, Department of Soil & Crop Sciences, Colorado State University, Fort Collins, Colorado.

Web Site: http://www.colostate.edu/Depts/SoilCrop/extension/Newsletters/news.html

Jessica Davis,
Technical Editor

Direct questions and comments to:
Deborah Fields
Phone: 970- 491-6201
Fax: 970-491-2758
E-mail: dfields@lamar.colostate.edu

Antibiotics in the Environment (continued)

phytoremediation (James Linden) at CSU in order to be prepared to give producers solid recommendations about management options to limit the spread of antibiotics in the environment.

Antibiotics used non-therapeutically in livestock production have been found in surface water bodies. What are the sources of contamination? Are the concentrations high enough to cause harm to humans or ecosystems? If the sources include livestock operations, what can be done to prevent further contamination? These are all questions whose answers are being sought out through CSU's research programs so that livestock producers can make sound decisions regarding their use and management of antibiotics in the future.

References

Boxall, A.B.A.; et al. Environ. Sci. Technol. 2003, 37, 287-294.

Kolpin, D.W.; et al. Environ. Sci. Technol. 2002, 36, 1202-1211.

Yang, S. and K. Carlson. Water Research 2003, 37, 4645-4656.

Jessica G. Davis
Extension Soil Specialist,
Dept. of Soil & Crop Sciences

Information on the Web

Cornell Cooperative Extension Food and Nutrition
This website highlights a congressional report, released in late April (1999) by the General Accounting Office, entitled The Agricultural Use of Antibiotics and Its Implications for Human Health. Specifically, the report examines 1) how antibiotics are used in agriculture and the implications of that use for human health, 2) the federal roles and responsibilities for overseeing the use of antibiotics in agriculture, and 3) the issues surrounding the debate over whether to further regulate or restrict the use of antibiotics in agriculture.
http://www.cce.cornell.edu/food/fsarchives/050699/antibiotics.html

Union of Concerned Scientists
UCS's antibiotic resistance project focuses on reducing the use of antibiotics in food animals.
http://www.ucsusa.org/food_and_environment/antibiotic_resistance/index.cfm

Animal Health Institute
This web site is provided by the Animal Health Institute, which represents manufacturers of animal health care products used to produce a safe supply of meat, milk, poultry and eggs, and the veterinary medicines that help pets live longer, healthier lives.
http://www.ahi.org/

The American Veterinary Medical Association
The AVMA Web site is the place where veterinary professionals, pet owners and animal lovers go to find comprehensive information on pet care and animal health.
http://www.avma.org/

The Sierra Club
A fact sheet on the problems from and solutions to adding antibiotics to livestock feed is available through the Sierra Club's Clean Water Campaign.
http://www.sierraclub.org/planet/200004/antibiotics.asp

Antibiotics in the Cache la Poudre River

Livestock and human antibiotics documented in the Poudre.

Human and veterinary pharmaceutical compounds in the environment have received increased attention in recent years. These medicines are used for therapeutic treatment of infectious diseases in humans and for treating and protecting the health of animals. In addition, veterinary antibiotics are used to promote growth and feed efficiency in a range of animals. For example, monensin is a common feed additive for beef cattle. The tetracycline class of compounds is the most widely used animal antibiotic in this country. Currently, two of the ten approved antibiotic growth promoters are tetracyclines, chlortetracycline and oxytetracycline. A fraction of the drugs is completely metabolized to inactive compounds, but a significant amount is excreted as active metabolites.

Researchers have shown that several classes of antibiotics (e.g., tetracyclines, sulfonamides, macrolides and ionophores) are present in hog waste lagoons at concentrations as high as 0.7 mg/L. A variety of residual antibiotics were found in sewage treatment plant (STP) effluents in Germany with concentrations as high as 5 µg/L. The U.S. Geological Survey measured concentrations of antibiotics in water samples from a network of 139 streams across 30 states during 1999 and 2000. This reconnaissance study indicated that these compounds were found in 80% of the streams sampled. Antibiotic concentrations as high as 1.9 µg/L were found and only 10 of 24 compounds measured were not detected in any of the streams. The frequency of detection of at least one antibiotic was 22%.

The presence of antibiotics in the aquatic environment has created two concerns. The immediate concern is the potential toxicity of these compounds to aquatic organisms and humans through drinking water. In addition, there is growing concern that release of antibiotics to the environment contributes to the emergence of strains of disease-causing bacteria that are resistant to even high doses of these drugs. Indications of increased bacterial resistance in waste effluent from hospitals and pharmaceutical plants have been reported, raising potentially serious public health issues associated with the ultimate disposal of antibiotics.

The origin of antibiotic contamination in surface and ground waters is considered to be both point and non-point source discharges of municipal and agricultural wastewater. Since few studies have been conducted on the occurrence, fate and transport of antibiotics in the environment, there are several questions that need to be answered on a regional and even watershed level. The most important questions that need to be addressed for a particular watershed relate to the occurrence and source (urban or agriculture) of these compounds. After these issues have been addressed, and assuming that the goal is zero discharge of antibiotics to the environment, watershed stakeholders should identify approaches for minimizing release from both urban and agricultural sources. The

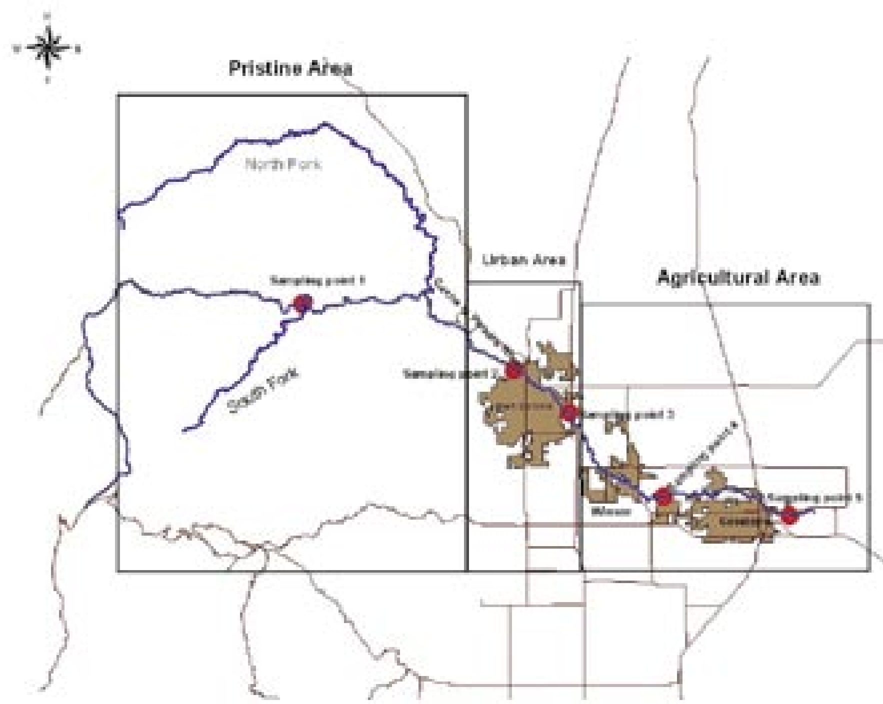


Figure 1. Sample collection points.

continued on page 5

Antibiotics in the Cache la Poudre River (Continued)

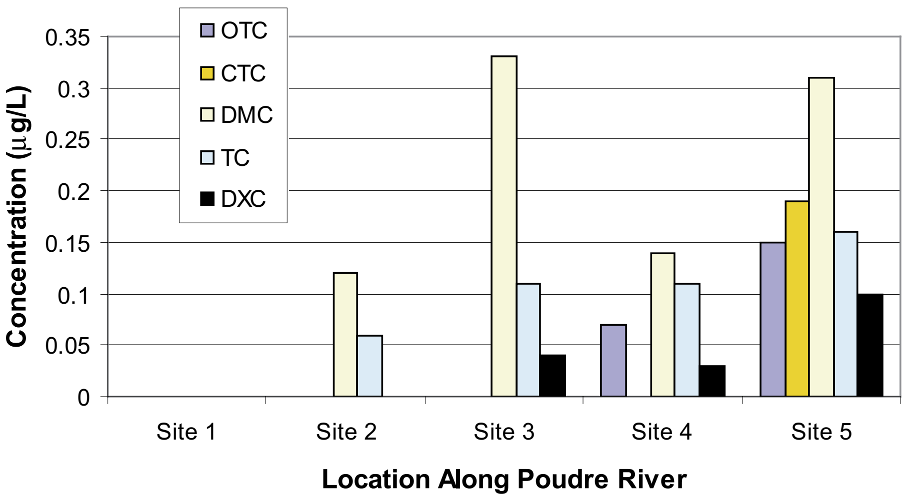


Figure 2. Occurrence of tetracyclines in the Poudre River.

objective of this article is to describe a study that is underway at CSU to answer these questions for the Cache la Poudre watershed in Northern Colorado.

A watershed-scale field study was conducted on the Cache la Poudre (Poudre) River (Figure 1). The Poudre River originates near the continental divide in Rocky Mountain National Park, flowing through steep mountainous terrain for approximately 43 miles before entering the Front Range city of Fort Collins. After traveling through Fort Collins, the river moves through approximately 45 miles of mostly agricultural landscape before joining the South Platte River in Greeley, CO. Due partly to the semi-arid nature of the Front Range of Colorado, there are no significant tributaries to the Poudre River and, therefore, the inputs to the river are predominantly point sources in the urban landscape of Fort Collins and non-point sources in the agricultural areas outside of the City. These factors coupled with the source being snowmelt with minimal anthropogenic influences make this an ideal watershed to study the occurrence and evolution of antibiotics through pristine, urban and agricultural landscapes.

Five tetracyclines including tetracycline (TC), oxytetracycline (OTC), chlortetracycline (CTC), doxycycline (DXC), and democlocycline (DMC), and six sulfonamides including sulfathiazole (STZ), sulfamerazine (SMR), sulfamethazine (SMT), sulfachloropyridazine (SCP), sulfamethoxazole (SMX), and sulfadimethoxane (SDM) were analyzed and quantified. In addition, the concentrations of three ionophore antibiotics (monensin, salinomycin, narasin) were determined at each of the five sites. The ionophore antibiotics are of interest since they are used exclusively in agricultural applications.

The results of the occurrence survey are shown in parts per billion (same as micrograms per liter) in Figures 2 through 4. At the five sites along the Poudre River that were monitored, the only site at which no antibiotics were detected was the pristine site in the mountains before the river had encountered urban or agricultural landscapes. By the time the river had exited Fort Collins (Site 3), 7 of the 13 compounds that were monitored were found in the samples. At Site 5 in Greeley, CO where the river converges with the South Platte River, all five of the tetracyclines monitored were present indicating both urban and agricultural influences.

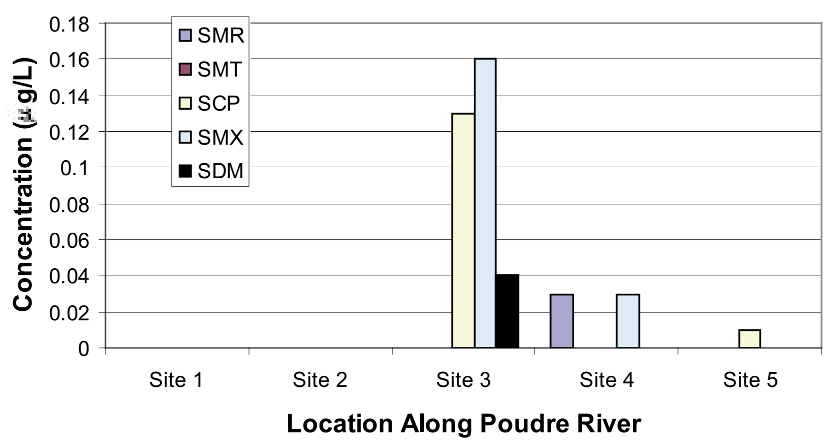


Figure 3. Occurrence of sulfonamides in the Poudre River.

continued on 6

Antibiotics in the Cache la Poudre River (continued)

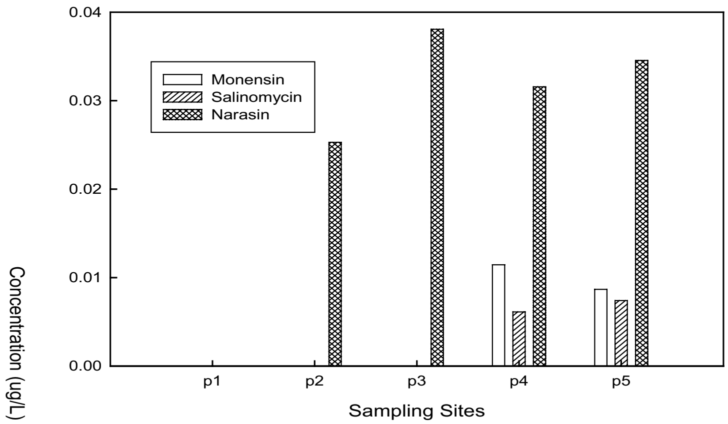


Figure 4. Occurrence of ionophores in the Poudre River.

Although 3 out of 6 sulfonamides were detected in the river leaving Fort Collins, only 1 of 6 was found at Site 5. This result indicates that sulfonamides were not originating from agricultural sources and that significant natural attenuation mechanisms were active in the river between site 3 and 5. Of the ionophores, only narasin was found at sites 2-5. Since this antibiotic is only used therapeutically with poultry, it is not clear what the source is. Monensin, a growth promoter in beef cattle, and salinomycin, used for prevention of coccidiosis in broilers, were found in the agriculturally influenced sample sites (4 and 5). A significant number and concentration of human and animal antibiotics have been measured in the Poudre River. The current phase of the study is identifying sources (wastewater treatment plants, animal waste lagoons, land application of wastewater, manure, and sludges) and future phases will identify strategies for minimizing the release of these compounds into the environment.

Ken Carlson, Shinwoo Yang, and Sung-chul Kim
Associate Professor and Graduate Students,
Department of Civil Engineering

Commercial Compost Classification and Quality Workshop

Hosted by: Colorado State University and the Rocky Mountain Organics Council

Wednesday, February 9, 2005 9 am-12:30 pm
**** lunch will be served following workshop****

Southwest Weld County Service Complex 4209 Weld County Road 24.5 (720) 652-4200
Cost: $20 per person
Please RSVP by Jan.15, 2005: (970) 491-6984 Addy Elliott or aelliott@ColoState.edu

Workshop Topics :

* **Compost classification**	* **Soluble salts**
* **pH**	* **Compost maturity (% germination)**
* **Ag Index**	* **Compost maturity (C:N ratio)**
* **Nutrient content/cycling**	* **Physical properties**

Exit 240 from I-25 and proceed east 0.1 mile. Turn north on frontage road and travel 0.5 mile. At Weld CR 24.5 turn east and proceed 2.3 miles. Turn left and travel 1.6 miles and you will see the complex. For a detailed map: www.co.weld.co.us/southcounty/index.html

Antibiotics in Animal Waste Lagoons and Manure Stockpiles

Antibiotic levels in manure and logoons vary widely.

Raising livestock for meat, milk and eggs has been an integral part of food production in the United States for centuries. The efficiency of the U.S. food production system is unsurpassed, and currently less than 2 percent of the population is involved with the production of food for the rest of the country. The high level of production efficiency can be attributed to scientific advances in breeding, genetics, nutrition, and animal health on the farm.

Veterinary medicines or drugs have become a critical component of the food-animal production system providing benefits related to animal health and growth efficiency. Since the benefits of sub-therapeutic use of antibiotics were discovered over 40 years ago, more and more animal feeding operations have begun using feedstocks fortified with these compounds for enhancing growth and feed efficiency. Additionally, the sub-therapeutic use of antibiotics in livestock has been credited with allowing concentrated animal feeding operations to exist, a key reason that the U.S. animal production system has become so efficient.

The advances that have been made in food production efficiency would not have been possible without gains in controlling disease in crops and animals. To a large degree, these gains are due to pesticides for crops and veterinary drugs for animals. The success of these chemicals in controlling disease has not come without negative side-effects. For example, the impact of pesticides on the environment has been well documented, and research has led to compounds that are less persistent and less mobile. We also have developed best management practices (BMPs) for accomplishing agricultural objectives with minimal impact on the environment. We are not nearly as far along with the process of understanding the impact of veterinary medicines on the environment or developing BMPs to minimize those impacts.

A critical question surrounding the recent discovery of antibiotics in the environment is the ultimate source: domestic wastewater, animal agriculture, or other sources. The objective of this study was to begin measuring the occurrence of a range of antibiotics in suspected sources. This document will describe the results of an occurrence survey of these compounds in liquid and solid residues associated with animal feeding operations, manure and lagoon water.

Measurement of relatively low concentrations of complex organic compounds in manure and lagoon water matrices is challenging. Methods that combined liquid-liquid extraction, solid-phase extraction, liquid chromatography and mass spectrometry were developed for quantifying three classes of antibiotics in manure and lagoon water matrices. The antibiotics that were measured included five tetracyclines (TCs) (tetracycline (TC), oxytetracycline (OTC), chlortetracycline (CTC), doxycycline (DXC), and democlocycline (DMC)), six sulfonamides (sulfathiazole (STZ), sulfamerazine (SMR), sulfamethazine (SMT), sulfachloropyridazine (SCP), sulfamethoxazole (SMX), and sulfadimethoxane (SDM)) and three macrolides (tylosin

Table 1. Animal feed operation waste streams sampled.

Operation	Lagoon Water	Manure
Dairy	7	7
Beef	6	5
Hog	10	5
Sheep	2	4
Turkey	0	2

continued on page 8

Antibiotics in Animal Waste Lagoons and Manure Stockpiles (continued)

(TLS), erythromycin (ETM) and roxythromycin (RTM)).

The waste streams from 25 animal feeding operations in Colorado were sampled for either manure, lagoon water or both. The number of operations that were sampled for each waste stream is shown by livestock type in Table 1.

The range of results for each class of animal antibiotic is shown in Table 2 for the lagoon water and Table 3 for manure samples.

The results of this occurrence survey indicate that a wide range of antibiotics is present in most animal waste streams, either runoff ponds, waste lagoons or manure stockpiles. The individual antibiotic results varied widely. For example, tylosin (a macrolide) was found in all but four waste lagoons sampled (an occurrence rate of 84%) but erythromycin and roxythromycin were found in only 36% and 10% of the lagoons sampled, respectively. Tetracycline (occurrence rate of 96%) and sulfadimethoxane (occurrence rate of 44%) were the most common compounds in their classes.

The concentrations of the antibiotic compounds also varied significantly as shown in Tables 2 and 3. The wide range of concentrations seems to indicate that feeding practices along with waste management procedures can significantly impact the fate of antibiotics in waste streams. The next phase of the project will attempt to relate these practices with antibiotic concentration in lagoons and manure stockpiles. We hope to be able to

provide guidance and BMPs to the animal agriculture industry on how to minimize the release of antibiotics to the environment. Since the data indicates that a significant amount of antibiotic compounds can concentrate in the manure, we will also study how manure management techniques influence the transport of antibiotics to the environment.

Ken Carlson, Shinwoo Yang, Jung-mon Cha, Kathy Doesken, and Jessica Davis
Associate Professor, Graduate Student, Graduate Student, Research Associate, and Extension Soil Specialist
Civil Engineering and Soil & Crop Sciences

Table 2. Concentration range of antibiotics in lagoon water.

Operation	Tetracyclines (µg/L)	Sulfonamides (µg/L)	Macrolides (µg/L)
Dairy	ND – 17	ND - 17	ND – 19
Beef	ND – 52	ND – 4	ND – 103
Hog	ND – 9490	ND – 2430	ND – 60
Sheep	ND – 6	ND – 133	ND – 2

ND non-detectable

Table 3. Concentration range of antibiotics in manure.

Operation	Tetracyclines (µg/kg)	Sulfonamides (µg/kg)	Macrolides (µg/kg)
Dairy	ND – 5130	ND – 46	ND – 5
Beef	ND – 585	ND – 258	ND – 846
Hog	ND – 23,140	ND – 38	ND – 6682
Sheep	ND – 10,900	ND – 419	ND – 31
Turkey	ND – 309	ND – 70	ND – 4

ND non-detectable

Potential for Phytoremediation of Antibiotic-Contaminated Water

Phytoremediation shows promise in antibiotic removal.

Contaminated soils and waters can pose major environmental and human health problems, which may be partially solved by emerging phytoremediation technology. Phytoremediation is a relatively new field in remediation technology, which uses plants' ability to degrade, assimilate, metabolize, or detoxify metals, hydrocarbons, pesticides, and chlorinated solvents. Plants can be used to treat systems containing many different types of contaminants including petroleum hydrocarbons, chlorinated solvents, pesticides, metals, radionuclides, explosives, and excess nutrients. Phytoremediation of metals and metalloids involves plant uptake and accumulation of the pollutant metal at concentrations that might be several fold higher than that in the polluted environment around the plant. In the case of organic compounds, plants act by volatilizing, transforming or degrading the pollutant. Experiments in our laboratory have shown that plants can be used successfully to remove antibiotics from water.

Experiments in our laboratory have shown the phytoremediation capability of aquatic plants and plant hairy root cultures in removing antibiotic growth promoters like oxytetracycline (OTC) and tetracycline (TC) from water. *Myriophyllum aquaticum* (parrot feather) and *Pistia stratiotes* (water lettuce) were the aquatic species, while *Helianthus annuus* (sunflower) was the root culture studied for antibiotic remediation. The aquatic plants were grown in Mason jars, and the roots were cultured in 250-ml Erlenmeyer flasks containing 75 mL of microbe-free plant medium. During the course of the experiments, antibiotic concentrations in the aqueous medium were analyzed by using an HPLC-based method (high performance liquid chromatograph with UV detection). Control experiments, performed without plants to determine antibiotic degradation due to light or natural conditions, did not reveal any significant results in the time frame that the phytoremediation effects of the plants were studied (maximum of two weeks).

Parrot feather demonstrated antibiotic removal rates ranging from 60 to 100% in water containing OTC/TC at concentrations up to 10 mg/L in 2 weeks, with the maximum removal occurring in the first two days. Water lettuce gave complete antibiotic removal within 6 days, and hairy roots of sunflower gave complete antibiotic removal within 7 days, for the same concentration range. Filtered root exudates from these plant systems gave comparable antibiotic removal. The disappearance of the antibiotics on the exposure to root exudates, in the absence of live plants, may be due to the presence of some rhizospheric compounds (like enzymes) that may degrade/transform the antibiotics. Figure 5 shows the results obtained for water lettuce on exposure to 5 mg/L of TC.

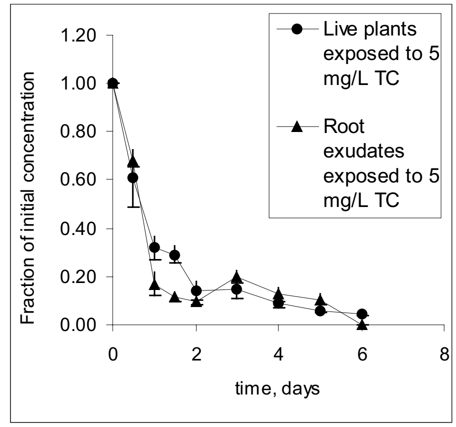


Figure 5. Disappearance curve for TC in *Pistia stratiotes* (water lettuce) at 5-mg/L initial concentration.

Similar disappearance curves were observed for both antibiotics with the other plant systems, as well.

Thus, aquatic species, as well as terrestrial plants (sunflower), have potential to remove antibiotics from water. For developing this potential into practical field applications, we have begun studies to evaluate water lettuce in greenhouse-scale wetlands. Although the potential for phytoremediation of antibiotic-contaminated water has been demonstrated, research and financial inputs are required to realize this potential in a practical situation.

Ninad Gujarathi and James Linden
Graduate Student and Professor,
Department of Chemical Engineering

Antibiotics: Are They a Threat to Aquatic Ecosystems?

Levels required for toxicity are usually higher than levels found in water.

In recent years, environmental toxicologists and chemists have discovered that drugs and their breakdown products, once assumed to be broken down in sewage treatment plants, are showing up in streams, lakes and coastal waters. Although much of the focus has been on drugs used in human medicine, there is also awareness of the possibility that animal drugs may also end up in these surface waters. Drugs (and their breakdown products) eliminated by animals usually do not go through the same kinds of treatment processes typical for human waste before reaching streams or groundwater. Unlike pesticides, which undergo extensive testing to determine potential environmental hazards before they can be put on the market, pharmaceuticals may not receive as much scrutiny.

Work in my laboratory is looking at the toxicity to aquatic animals of some of the drugs commonly used in food animals. We hope that our results will provide a better basis for sound judgments about environmental risks that may be associated with the use of these drugs. This is an important part of the equation when it comes to making decisions about managing animal wastes to reduce potential environmental problems that may become the focus of regulatory scrutiny.

A fundamental principle that governs the toxic effects of any chemical on a living organism is that the likelihood or extent of the effect is governed by the amount of the chemical absorbed by the organism. Toxicity is therefore related to the amount of the chemical in the environment, how much of it is actually absorbed and how potent it is in causing harmful effects in the particular species exposed.

For aquatic animals, exposure to a chemical can result from contact with it dissolved in water, bound to sediment or present in the animal's food. Some chemicals dissolve well in water; others stick to sediment at the bottom of a stream or suspended in the water. It is important to understand how a chemical behaves in the aquatic environment so that we have an idea of how animals might be exposed to it. This information allows us to identify the most appropriate approaches for designing laboratory studies that accurately reflect how aquatic organisms will be exposed in the environment.

In most of our studies, we start by using an aquatic flatworm (*Planaria*) to screen chemicals for toxicity. This species is inexpensive and easy to work with and can be exposed to chemicals dissolved in water or mixed with sediment. Further testing is conducted on chemicals of interest using other organisms, such as a tiny crustacean (*Hyalella*) or larval fish (fathead minnows) that are more labor-intensive (and expensive) to work with. This allows us to observe the effects of a chemical in a range of species that may differ in their sensitivity. Larval fathead minnows

and *Hyalella* are also widely used for toxicity testing for regulatory purposes.

Our initial studies have shown that many of the drugs used in animals have low toxicity to aquatic life. This includes chlortetracycline, tylosin, sulfamethazine and metronidazine, drugs representing a variety of types and uses.

The ionophore antibiotics, monensin and lasalocid, appear to be substantially more toxic to the aquatic organisms that we have tested so far. Because of its widespread use in cattle feed, we have focused our current efforts on monensin. It was found to be relatively toxic to fathead minnow larvae when present in water and to invertebrates (both flatworms and *Hyalella*) when added to sediment. For fathead minnows, the median lethal concentration was approximately 5 parts per million in water. Sediment concentrations of 20 ppm were toxic to *Planaria*, but 1 ppm was lethal to *Hyalella*.

So far, we have mainly looked at the lethal effects of monensin. Some

continued on 11

Antibiotics: Are They a Threat to Aquatic Ecosystems? (continued)

preliminary work with *Planaria* suggests that monensin may affect behavior related to survival at sublethal concentrations. If monensin causes similar effects on swimming speed and responses to environmental stimuli in fish, lower environmental levels of this drug may be of concern because of effects on survival.

Ken Carlson's studies on the Cache la Poudre River (page 4) showed that monensin concentrations were well below those shown to be toxic in our studies. However, a recent report from Canada suggested that sediment levels of monensin could approach those causing toxicity in our experiments. We are currently trying to determine how much monensin is present in water and sediment in different streams in northern Colorado. We are also seeking funding to do similar work in a Nebraska watershed with a high density of cattle feeding facilities.

Our studies suggest that there may be reason for concern that ionophores may affect aquatic life. We are continuing our work in this area to see if we can better define the concentrations of monensin in environmental systems that will adequately protect aquatic life, through a combination of laboratory and field research.

Howard Ramsdell, Associate Professor
Department of Environmental and Radiological Health Sciences

Meet Dr. Amy Pruden

Dr. Amy Pruden is an Assistant Professor in Civil Engineering and has recently begun research on agricultural antibiotics through financial support of USDA and the CSU Agricultural Experiment Station. Her main interest is to determine the effect of antibiotics on the spread of resistant microbial populations in the environment. Her concern is that while it is important to handle animal waste properly to ensure degradation of any residual antibiotics present, it is also important to make sure that antibiotic resistance genes are not spread into the environment. Spread of antibiotic resistant microbes is a major concern for human health, as we work to find treatments for human infection that effectively kill pathogenic microbes. Dr. Pruden spent this past summer mentoring an undergraduate engineering student, Katie Huxford through the Colorado Institute of Technology Summer Bridges Program. Under her guidance, Katie and Ruoting Pei (a Ph.D. student) developed and tested several gene probes for tetracycline resistance genes, an antibiotic commonly used both in humans and animals. Recent results have shown that these genes are indeed present in the Poudre River, and correlate both with urban and agricultural activity. The important step now is to examine the situation fully to determine the true impact and whether there is cause for concern to human health. In the mean time, Dr. Pruden will be investigating simple steps that may be taken to minimize the risk. For example, she and graduate student, Heather Lambert, are evaluating the process of composting animal waste as a means to minimize the spread of antibiotic resistance genes. On the personal side, Dr. Pruden was married last December in Calcutta, India. She is particularly interested in environmental issues on a global scale, and enjoys language and culture. This Fall semester she is team-teaching a new course on "Water Engineering for International Development."

Future Plans

Funding from the Colorado Agricultural Experiment Station and the USDA National Integrated Water Quality Program has been procured by CSU to expand on the research that has already been accomplished in the area of antibiotics in the environment. There are two broad categories of research involved: 1) Antibiotics in the Poudre River, and 2) Manure Management Effects on Antibiotics.

In the Poudre River, we are developing an occurrence database of 16 antibiotics through pristine, urban and agricultural landscapes, including both the water column and the benthic sediments. Our goal is to be able to determine the source(s) of antibiotics in the Poudre River. We will develop an occurrence database of antibiotics in the influent and effluent of the Fort Collins Wastewater Treatment Plant to determine temporal variability of occurrence and removal in the plant. We are also in the process of evaluating how antibiotics might be transported to the river from each source: lagoon seepage, lagoon overflow, runoff or leaching from manured fields. Assessment of the impact of the zonation of the Cache la Poudre River watershed on the microbial community structure of the benthic sediment is underway, and antibiotic resistance genes are being quantified in the sediment. This data will aid in determining the magnitude of the effect of antibiotics measured in the stream.

In case CAFOs are identified as a source of antibiotics in the Poudre River, we are working on understanding the effects of manure management practices on the presence and degradation of antibiotics. In addition to measuring antibiotic levels in manure and effluent, we are evaluating impacts of lagoon aeration and composting on antibiotic concentrations and the presence of antibiotic resistance genes.

Finally, we will develop a model for predicting the fate of antibiotic compounds in animal waste lagoons and wastewater treatment plant effluents and compare the model results with the occurrence of antibiotics in the Poudre River. Through Cooperative Extension, we will disseminate information on design and operation of animal feeding operations in order to minimize the release of pharmaceutical compounds to the environment.

Jessica Davis, Ken Carlson, and Amy Pruden
Extension Soil Specialist and Professor, Associate Professor, and Assistant Professor
Depts. Of Soil & Crop Sciences and Civil Engineering