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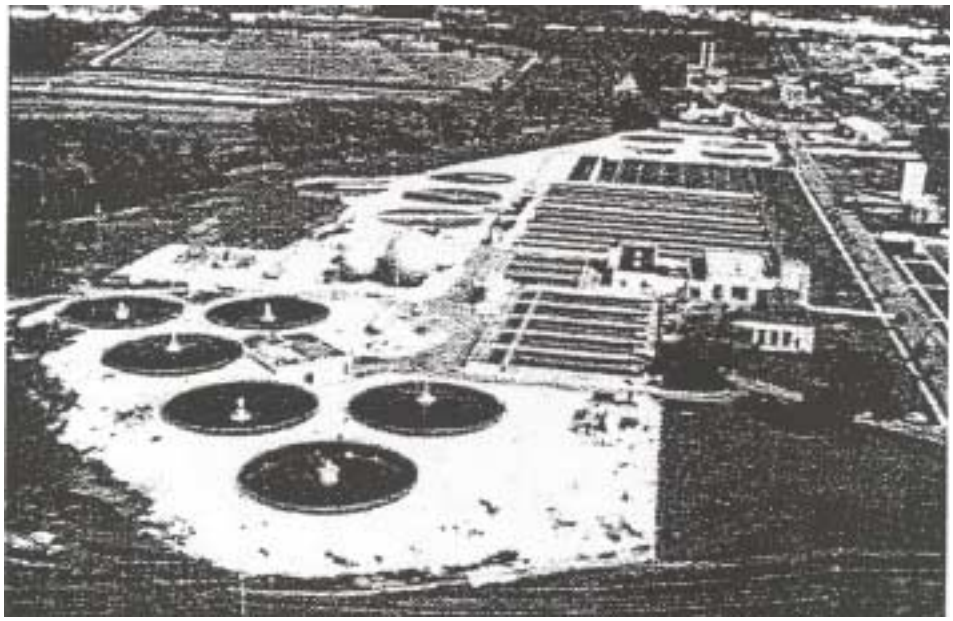

ANTIBIOTICS AND OTHER CHEMICALS ARE SHOWING UP BELOW WASTEWATER TREATMENT PLANTS

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Information recently collected by a team of chemists with the U.S. Geological Survey, indicates that several new classes of chemical contaminants are being found in the flesh of fish below wastewater treatment plants. German and other European chemists are reporting similar findings. These chemicals include fragrances used in perfumes, shampoos and detergents; sun-blocking compounds from sunscreen lotions; personal health and beauty aids; and a wide array of pharmaceuticals and drugs.

The environmental impacts associated with most of these chemicals is probably very minor. However, scientists and public health officials are very concerned about two of the chemical classes--antibiotics and hormones--because of their potential environmental impacts. Concern for other chemical classes may increase following further study.

Organisms and Chemicals

All living organisms, including humans, are comprised of inorganic and organic chemicals. However, some chemicals (both naturally occurring and synthetic), can have detrimental affects on humans or other organisms upon exposure. Much of our research endeavors involve either limiting human (and other organism) exposure to harmful chemicals or purposely exposing problem-causing organisms to chemicals to destroy them.

All organisms must extract essential needs from their surroundings to survive. Most of these needs are various forms of chemicals that the organisms consume for energy or use to produce other chemicals. Organisms must also avoid chemicals which are toxic to them, or develop methods to neutralize such chemicals.

In an ever-changing environment that now includes a multitude of synthetic and naturally occurring chemicals, all living organisms make continuous adjustments to better obtain chemicals they need and to better avoid or tolerate toxic chemicals. This continuous adjustment of living organisms to their surrounding environment is called **evolutionary adaptation**. Some organisms are much better and faster at making these adjustments than others.

The survival of many microorganisms depends on their ability to make a host of other living organisms to obtain their nutritional needs. This is what happens when infectious bacteria invade the human body. Since humans have a much slower pace of evolutionary adaptation than microbes, many microorganisms (such as bacteria) can invade and colonize the body because they have evolved to defeat natural human defense mechanisms.

To help us fight off disease-causing organisms we ingest **antibiotics**. The discovery and use of antibiotics has saved millions of lives.

Antibiotics and Their Use

An antibiotic is defined as any chemical substance that has the capacity to inhibit the growth or destroy bacteria and other microorganisms which cause infectious diseases in humans. Many chemicals have antibiotic effects, but to be effective, an antibiotic must be harmful to disease-causing microbes but harmless to the human system--a very delicate balance. Those chemicals capable of killing at very low concentrations are most desirable because they usually have less side effects.
The use of antibiotics has grown tremendously since sulfa drugs were discovered in 1904. By the mid 1960s, more than 5000 sulfa drugs had been prepared and tested. But not until **penicillin** was first used on humans in 1941, did we have an effective antibiotic for killing both gram-negative and gram-positive bacteria as well as most protozoan organisms.

Many of our important antibiotic drugs, including **streptomycin**, penicillin and the tetracycline drugs such as **aureomycin**, are produced by and extracted from fungi or other microorganisms. These organisms actually produce these chemicals as a defense mechanism against other microbes.

We are constantly searching for new and better antibiotic chemicals to replace those that become ineffective due to organism resistance. Also, some effective antibiotics like streptomycin have been abandoned because of their negative side effects.

Antibiotics have been used globally for more than half a century to treat human diseases. In the more developed countries, antibiotics have also been widely used for general disease prevention in household pets and farm animals. This widespread use of antibiotics and their dispersal in low concentrations throughout our environment may lead to problems.

Evolutionary Immunity to Antibiotics

If disease-causing bacteria are continuously exposed to antibiotics, it is likely that they will accelerate their adaptation to these chemicals through evolutionary mutations. This has happen with a number of organisms already. For example, within the past 50 years, the bacterium *Pseudomonas aeruginosa* has emerged as one of the most opportunistic infections in humans because of its ability to rapidly mutate. This bacterium is remarkably versatile and capable of persisting in soil, water, and in the tissues of plants, humans and even nematodes.

One of the growing fears of scientists and public health officials is that disease-causing bacteria such as *P. aeruginosa* may become immune to treatment by our standard antibiotics. The recent discovery of low levels of several antibiotics in many surface and groundwater supplies around the world has further elevated these fears.

Information on antibiotic resistance may be obtained from the Centers for Disease Control and Prevention. The URL is: *http://www.cdc.gov/ncidod/dbmd/antibioticresistance/*.

Antibiotics in Water: Where Do They Come From?

Waste streams from human population centers, concentrated animal production areas, and medical facilities are the three primary sources for antibiotics in water. We flush these antibiotics along with all sorts of other chemicals down our toilets and drains. Many are apparently passing right through wastewater treatment plants into our rivers, lakes and aquifers.

Most wastewater treatment plants were designed to disinfect, remove certain inorganic chemicals, and screen out solid wastes, not to remove low concentrations of dissolved organic chemicals. These plants effectively remove most solid wastes and chemicals, but do not remove all drugs nor other household chemicals from the wastewater stream.

Researchers with the U.S. Geological Survey have reported finding a variety of antibiotics just downstream from hospitals, municipal wastewater treatment plants and concentrated animal operations in a number of states.

Human ability to break down medicine varies widely by individual and by drug. We now know many drugs are not totally decomposed within the body. A portion of these drugs is excreted in feces or urine. The same is true with domesticated animals.

The situation with animal feeding operations (AFOs) is that both feed wastes and manures may contain antibiotics. Most of these wastes are land-applied to recover plant nutrients. Until recently, there was little concern that pharmaceuticals or other chemical feed additives might lead to water contamination. Limited research indicates that such chemicals may move from sites where manures and sewage sludges have been applied into nearby water supplies.

Hormones in Water: Where Are They Coming From?

Hormones, another class of chemical contaminants recently found in water, have scientists and environmentalists concerned. Scientists in several countries, including the U.S., have found the female sex hormone, estrogen, as well as estrogen replacement

drugs, in many water supplies. Over 8 million women in the U.S. alone take a single estrogen replacement drug to treat the symptoms of menopause and osteoporosis. Both male and female hormones are used in feeds that go to millions of food production animals.

Some scientists are already hinting that estrogen or estrogen replacement drugs may be responsible for deformities occurring in the reproductive systems of fish. Both American and British scientists have observed fish reproductive abnormalities just downstream from a number of municipal wastewater treatment plants. Plans are under way to look for reproductive abnormalities in amphibians and other animals that feed on aquatic organisms.

Industrial chemicals and pesticides have received most of the blame for fish reproductive abnormalities in the past. Synthetic organic chemicals that imitate natural hormones have not been ruled out, and still may be causing reproductive disorders in fish or other animals. However, further research may reveal that birth control pills and estrogen treatment drugs are to blame for these reproductive abnormalities.

Other New Classes of Chemicals in Water

Through an expanded testing program, the U.S. Geological Survey has found other chemicals in water not generally thought of as contaminants. These new classes of chemicals include general hygiene and beauty aids, perfumes, skin and hair care products, cleansing agents, and a wide array of pharmaceuticals. Drugs found include caffeine, codeine, cholesterol-lowering agents, anti-depressants and chemotherapy drugs. Caffeine was found to be one of the highest-volume contaminants in wastewater and is now used as an indicator for municipal wastewater contamination levels.

What Does All This Mean?

Before drawing conclusions, it is important to note that water is a 'super solvent' that moves throughout our environment encountering billions of chemicals. For example, there are more than 100 different chemicals in coffee's aroma alone.

It is also important to realize that we are finding these chemicals in water because we are now looking for them, and recent advances in our pollution detection technologies are allowing us to find them. The mere presence of these chemicals in water does not indicate real problems, but it makes us suspicious, because we know our water supplies are not free from contamination by our most common every-day-use chemicals.

If antibiotics and sex hormones are reaching surface and ground water supplies at levels that cause real problems (to be determined), we must be more vigilant in how we use pharmaceuticals and in how we manage wastes.

From the veterinary perspective, both antimicrobials and hormones are very important to food producing animals. Antimicrobials control the spread of infection and hormones accelerate weight gain. However, if these chemicals are moving from their targeted use to cause general negative environmental impacts, we need greater emphasis on vaccination, better hygiene and better waste management practices.

If chemicals are moving through municipal wastewater streams to significantly impact our health and environment, then arid areas such as the western U.S. are especially vulnerable. Many streams in such areas rely almost entirely on treatment plant effluent during dry seasons. Also, many western cities use wastewater to replenish aquifers that supply drinking water.

The most significant conclusion from these findings may be confirmation that every individual, whatever he/she does, affects the environment in one way or another.

Further Studies

The U.S. Geological Survey has scheduled a series of tests in the year 2000 at 100 sites in 24 states. The results will provide the first national assessment on the occurrence of drugs, sex hormones, and other unexplored contaminants in U.S. water supplies.

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