Update on Emerging Contaminants: **Pesticides**

The Use of Pesticides: A History

The use of pesticides to control unwanted pests dates back hundreds of years. Early pesticides were mainly inorganic chemicals such as calcium arsenate, lead arsenate (both now banned in the United States), and fluoroorganic compounds[1]. Modern science has since produced hundreds of synthetic organic chemicals for use as pesticides. In fact, approximately 900 active pesticide ingredients are registered in the United States for use in nearly 20,000 pesticide products[2].

WHAT IS A PESTICIDE?

A pesticide is a general term defined by the United States Environmental Protection Agency (USEPA) as “any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest.” Examples of pests are insects, weeds, or microorganisms (bacteria and viruses). The most common way to classify pesticides is by the target organism, such as herbicides (weed control), fungicides (fungi control) and insecticides (insect control). Pesticides are unique in that they are intended to cause damage to living organisms. Some, such as DDT (dichlorodiphenyltrichloroethane), are persistent in the environment and can therefore be passed through the ecosystem into contact with humans.

USE OF PESTICIDES

Large quantities of pesticides are used all over the world. In 2001 in the US, the use of conventional pesticides exceeded 1.2 billion pounds (lbs), a fraction of the worldwide usage of 5 billion lbs[3]. The most widely used conventional pesticide in the world is the herbicide 2,4-D (or 2,4 dichlorophenoxyacetic acid). Introduced in 1946, 2,4-D is a chlorinated phenoxy compound that is used to control many types of broadleaf weeds. It is used in agriculture, in rangeland applications, home, garden, and to control aquatic vegetation. Agent Orange, used extensively in the Vietnam War, was about 50% 2,4-D. The most widely used pesticide in the US is glyphosate. Glyphosate (*N*-(phosphonomethyl) glycine) is a broad spectrum systemic herbicide used to kill weeds, perennials in paticular. In 2001, between 85 and 90 million lbs of glyphosate were applied to crops in the US[3]. Other widely used pesticides include atrazine (a herbicide), metam sodium (a fumigant), and acetochlor (a herbicide).

PESTICIDE REGULATION

Regulating bodies attempt to balance the toxicological risk against the beneficial aspects of pesticide use. In the US, pesticides are regulated in two primary ways. First, each pesticide must be registered under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This Act establishes a regulatory system for controlling the sale, distribution and application of pesticides. Second, the USEPA has issued National Primary Drinking Water Regulations (Maximum Concentration Levels, or MCLs) for over twenty pesticides, including atrazine (3 parts per billion [ppb]), alachlor (2 ppb), and dibromochloropropane (DBCP, 0.2 ppb)[4].

In Europe, each pesticide is subject to an approval process by the European Union. Also, the European Union regulates the levels of pesticides in drinking water through the Water Framework Directive[5]. Under European regulations, the total concentration of pesticides in drinking water may not exceed 0.5 ppb, while the concentration of any one pesticide may not exceed 0.1 ppb.

THE EFFECTS OF PESTICIDES ON HUMAN HEALTH

Much research has been performed on the toxicity of pesticides. Many pesticides are carcinogenic to animals and, for this reason, are likely human carcinogens. For example, the pesticides alachlor,

EXAMPLES OF PESTICIDE CHEMICAL CLASSES

TRIAZINE HERBICIDES

- Atrazine
- Cyanazine
- Simazine

CHLOROACETAMIDE HERBICIDES

- Alachlor
- Metolachlor
- Acetochlor

PHENYL-UREA HERBICIDES

- Diuron
- Fenuron
- Isoproturon

ORGANOPHOSPHATE INSECTICIDES

- Diazinon
- Malathion
- Chlorpyrifos

FACT**SHEET**

TOP 5 MOST COMMONLY USED CONVENTIONAL PESTICIDES IN THE US (2001)[3]

RANK	PESTICIDE	MILLIONS LBS ACTIVE INGREDIENT
1	Glyphosate	85-90
2	Atrazine	74-80
3	Metam Sodium	57-62
4	Acetochlor	30-35
5	2,4-D	28-33

dieldrin, and DBCP are each classified under the USEPA designation "probable human carcinogen."

Perhaps the greatest threat posed by pesticides, however, is their endocrine disrupting potential. Pesticides such as atrazine, malathion, methoxychlor, and many others have been shown to disrupt endocrine systems, even at very low concentrations. Exposures can cause reproductive system damage including sterility, decreased fertility, and birth defects, as wells as impaired development, immuno-suppression, and metabolic disorders. Studies have linked low concentrations (0.1 ppb) of the pesticide atrazine to developmental deformities in frogs including the development of multiple sex organs and small feminized larynxes[6]. In another study, frogs exposed to even trace amounts of malathion experienced a near total collapse of their immune systems, with antibody production limited to as little as 1-2% of normal[7]. Currently, scientists are working to better understand the impacts of such chemicals on humans and aquatic animals.

PESTICIDES AS MICROPOLLUTANTS IN THE WATER SUPPLY

Numerous studies have been performed in North America and Europe to determine the extent of agricultural pesticide migration into streams, rivers, lakes and groundwater. The National Water Quality Assessment Program coordinated through the United States Geological Survey (USGS), for example, has compiled data on pesticide concentrations in US waterways since 1989. A portion of this research conducted between 1992 and 1996 included analysis of 76 pesticides in over 8,000 samples collected from streams, rivers and groundwaters in 20 major watersheds in the US. Results of this study revealed that at least one pesticide was detected in at least 95% of the samples collected in streams and rivers and in 50% of groundwater samples. The most frequently detected pesticides were the herbicides atrazine and metolachlor, followed closely by cyanazine, and alachlor[8].

TREATMENT ALTERNATIVES – UV LIGHT A KEY

Conventional water treatment technologies such as chlorination, coagulation and filtration do little to remove pesticide contaminants from water. Other technologies such as carbon adsorption and ozonation are feasible but costly in large-scale treatment applications. Ozone treatment can also form harmful by-products such as bromate. However, advanced oxidation using UV light and hydrogen peroxide is a highly cost-effective solution for treating pesticides. The photolysis reaction breaks apart pesticide molecules upon exposure to UV light while oxidation involves the UV photolysis of hydrogen peroxide to generate hydroxyl radicals. The hydroxyl radical is one of the most powerful oxidizing species known and reacts rapidly with organic constituents in the water, including pesticides, breaking them down into harmless components. Trojan's advanced oxidation technologies provide a proven and reliable barrier to pesticides in the water supply.

TREATING MULTIPLE CONTAMINANTS WITH ONE UV SYSTEM

As an added benefit to pesticides treatment, upon passing through a Trojan UV oxidation reactor the water is disinfected (inactivating pathogenic microorganisms including *Cryptosporidium*) and treated for other dissolved organic compounds that may be present. These other compounds may include other endocrine disruptors, *N*-nitrosodimethylamine (NDMA), volatile organic compounds (VOCs), or taste and odor-causing compounds (such as MIB and geosmin).

For over 30 years, Trojan Technologies has specialized in UV light applications for water treatment and wastewater disinfection. Over 5,800 Trojan UV systems are treating municipal wastewater in more than 80 countries around the world. Tens of thousands of industrial and residential Trojan UV treatment systems are in operation in industries and households worldwide. Now, Trojan offers the industry standard in Environmental Contaminant Treatment (ECT). Trojan's photolysis and advanced UV oxidation systems are capable of cost-effectively removing environmental contaminants such as pesticides, NDMA, endocrine disruptors, 1,4-dioxane, and taste and odor-causing compounds from a variety of water streams. In addition to extensive in-house research, Trojan has formed an alliance with the PWN Water Supply Company North-Holland, located in the Netherlands, to further optimize the treatment of micropollutants, including pesticides, with UV light. With its optimized technology, Trojan is the leader in ECT, offering the most cost-effective, highest quality UV solutions available.

References:

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