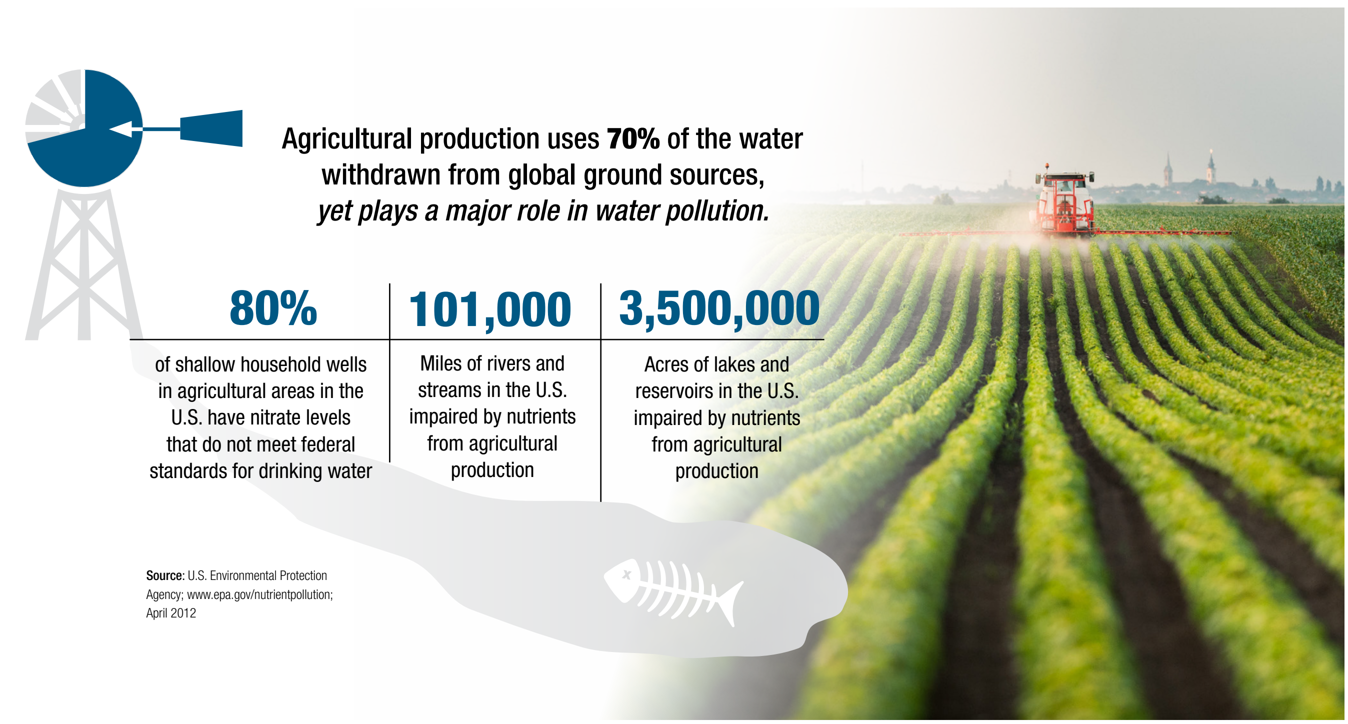
Pesky Pesticides: Environmental Risks with Agricultural Operations

Agricultural operations play a major role in today's environmental pollution concerns. Erosion of agricultural land can discharge large quantities of sediment which often contain harmful chemicals, such as pesticides – a broad term for substances meant to manage pests and includes herbicides, and insecticides. Agricultural pests can include a wide array of insects, mites, weeds, fungus and plant disease, parasitic worms and even rodents.



How do agriculture pesticides impact the environment? Pesticides and their residues remain in the environment long after application and can drift far beyond their target areas. The movement of pesticides into groundwater and surface water has the potential to impact drinking water sources resulting in unintended environmental risks. Certain pesticides can also pose vapor intrusion threats or bioaccumulate in the food chain.

Why are pesticides harmful to human health? Modern pesticides are typically synthetic organic chemicals that can possess toxic properties. Direct exposure and ingestion of pesticides has been associated with both, acute and delayed health effects, ranging from simple skin and eye irritation to more severe impacts on the nervous and reproductive systems.[1]

SECTION I

History of Chemical Control

Chemical control of agricultural pests has been in practice for centuries. Some of the earliest forms of pesticides consisted of petroleum and oils, where highly refined paraffinic oils were applied to crops to manage fungal and insect pests. These oils evaporated quickly after application and generally did not contaminate the soil or groundwater.[2]

Prior to World War II, in addition to oils, pesticides generally consisted of chemicals derived from natural sources such as nicotine, pyrethrum (chrysanthemum flower) as well as inorganic compounds such as sulfur, arsenic, lead, copper and mercury. Arsenic-based pesticides were dominant until the 1940s when new synthetic organic compounds were discovered, and the agricultural use of synthetic pesticides quickly grew nationwide.

Synthetic organic pesticides provided farmers with more options and increased the efficiency of crop production by providing superior protection and reducing the need for manual tillage.

By 1980, agriculture used **72%** of all pesticides applied in the United States with herbicides and insecticides accounting for **89%** of that quantity. U.S. Environmental Protection Agency (EPA) studies have shown that commercial agriculture – specifically, 21 crops grown domestically – has consistently accounted for nearly **75**% of pesticide use in the country from 1964 to 2007.[1]

> During this timeframe increased public concern and increased regulatory scrutiny changed the landscape of which pesticides could be used and applied.

SECTION II

Regulatory Framework

Pesticides have been regulated federally since the early 1900s and throughout the decades the standard framework has become more stringent:[3]

1947: New regulations were established under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which required pesticides to be registered with the U.S. Department of Agriculture (USDA) before sale and packaging to explicitly state if the substance was poisonous.

Mid-1960s: The publication of Rachel Carson's Silent Spring in 1962 brought attention to the environmental consequences of pesticide use. Around the same time, FIFRA was amended to give USDA authority to deny, cancel and immediately suspend use of pesticides to prevent imminent risk to humans and the environment.

1970s: Congress transferred responsibility for administering FIFRA to EPA. The newly created agency was additionally tasked with conducting scientific reevaluations for previously approved pesticides**.** EPA determined that pesticides such as DDT, aldrin, dieldrin, chlordane, and heptachlor, posed unreasonable risks and their registrations were canceled and their use was prohibited.

1980-1990s: The required EPA assessment include a 10-fold safety factor for childhood exposure. Under tightening standards, herbicides like atrazine, cyanazine, simazine, alachlor and metolachlor were accompanied with use advisories and restrictions. New pesticides with novel active ingredient formulations are still being created each year and each is subject to EPA review and approval.

While pesticide approvals are regulated at a federal level, state agencies typically take the lead when regulating clean-up objectives for legacy pesticide contamination in soil, surface water and groundwater. For example, in the 1990s, in the absence of federal regulations requiring sampling of agricultural land prior to redevelopment, New Jersey Department of Environmental Protection (NJ DEP) was the first agency in the nation to assess historical pesticide contamination on a statewide level. NJ DEP's Historic Pesticide Contamination Task Force focused on the presence of arsenic, lead, aldrin, dieldrin, DDT and DDT breakdown products – DDE and DDD. Historic pesticides like these, with acute toxicity and ability to persist in the environment, pose the biggest human health exposure.

In California, there is a dedicated Department of Pesticide Regulation (DPR). The California DPR issues state standards for pesticides in drinking water which in some instances are more stringent than the Maximum Contaminant Level (MCL) established federally by the EPA. State specific standards should be reviewed on a case-by-case basis when evaluating the potential pesticide risk.

SECTION III

Environmental Pollution Exposures

Whether it be Rachel Carson unveiling how DDT caused declining bird populations or the countless stories of Agent Orange's lasting affects in Vietnam, it has long been known that pesticides can pose a significant threat to the environment and human health.

> Pesticides can persist and migrate in the environment posing a potential exposure risk beyond property bounds and the typical occupational exposures associated with agriculture.

A greater population, beyond farmworkers, can be exposed to pesticides through three main pathways:[4]

- ***Ingestion***
- ***Inhalation***
- ***Direct contact***

Pesticide Ingestion

Pesticide ingestion can occur in several ways including drinking contaminated water, eating food products with pesticide residue, or accidentally consuming pesticides during hand to mouth activities (such as children playing in soils). Though EPA regulates pesticide residue limits to protect consumers, ingestion is still the most significant exposure route from a toxicology standpoint as the pesticides are being processed through internal organs. Potential chronic effects of pesticide ingestion include benign or malignant tumors, birth defects, genetic changes, reproductive effects, blood disorders, and endocrine disruption. Over 100 pesticides are considered endocrine disruptors, meaning they interfere with the body's hormones, which can lead to developmental, brain and immune disorders.

Inhalation

While not as significant of an exposure, certain pesticides - including chlordane, aldrin and lindane - can volatilize and pose an inhalation risk. Chlordane especially has very low indoor air quality thresholds which makes achieving acceptable residential levels in some states extremely difficult and quite costly. Vapor intrusion risks need to be evaluated closely if these pesticides are present.

Direct Contact

Dermal contact is often less serious as many pesticides cannot be adsorbed through the skin and will often only result in a rash. However, studies have shown that prolonged direct exposure during pesticide application and crop harvesting can result in serious illness. Occupational exposure to pesticides not only increases the general risk of cancer but has also been shown to increase the likelihood of other conditions like cardiovascular disease, Parkinson's disease and heart attacks.

SECTION IV

Pesticides in the Environment: Transport and Breakdown

Pesticides and their residues remain active in the environment after application and can drift far beyond their target areas through natural transport mechanisms such as air, water, soil erosion or leaching. However, not all pesticides behave similarly, and many factors determine the fate and future exposure risk each might present.

Both environmental factors (soil type, compaction, pH, etc.) and chemical composition determine the fate of a pesticide. Chemical composition will determine the *sorption potential, solubility, and persistence* (i.e., natural half-life) of a particular pesticide.[5,6]

Pesticide Sorption	
Chemical affinity to bind to soil particles.	
High Sorption Potential Bind more tightly to soil particles and are immobilized – often migrate with sediment in surface water runoff.	**Low Sorption Potential** Lower affinity to bind with soil particles - leach more readily through the soil column, migrating deeper.

Pesticide Persistence	
Stability in the environment and resistance to being broken down.	
Inorganic Many contain heavy metals like arsenic which do not break down naturally.	**Organic** 'Persistent' if they have a half-life longer than 100 days and those with a half-life less than 30-days are considered 'nonpersistent'.

The "half-life" concept only applies to pesticides which contain carbon components (i.e. organic/organo-pesticides). Pesticides with longer half-lives are more likely to build up in the environment after repeated applications, which increases the risk of contaminating nearby surface water, groundwater, plants, and animals as concentrations accumulate. Pesticides with long half-lives, low sorption potential and high solubility (ability to dissolve in water) are most likely to leach and contaminate groundwater.

Several external factors also affect the fate of pesticides in the environment beyond chemical composition. Pesticides can bioaccumulate in plant and animal tissue. Pesticides can also breakdown from exposure to sunlight, water from irrigation or precipitation and/or from microbial activity in soils. However, if a pesticide has a strong affinity for soil sorption, it is less likely to be subject to these other degradation processes.

Regardless of the degradation process, pesticides will break down to form new chemicals that may be more or less toxic. Pesticide degradation can lead to the formation of metabolites or otherwise referred to as daughter products. For example, DDE and DDD, which are daughter products of DDT.

SECTION V

Orchards: A Closer Look

Historically, arsenic-containing compounds were the most prevalent pesticides applied at fruit orchards. In the 1800s, pesticides known as Paris Green, a mixture of copper and arsenic, and London Purple, a mixture of calcium, arsenic, and organic matter, were the two most common pesticides used on fruit trees. Later, lead arsenate became the preferred pesticide and dominated orchard applications, especially apple orchards, until the 1940s when synthetic pesticides emerged.[7]

> Arsenic and other metals contamination (i.e., lead) is likely to be encountered at properties with a history of orchard use. Arsenic is persistent in the environment as it is very soluble in water and will readily disperse in groundwater and surface water.

DDT replaced lead arsenate as the preferred pesticide in the mid-20th century until it was later banned in 1972. Though DDT and other synthetic chemicals tend to be less persistent than the arsenic-containing pesticides, their metabolites, or breakdown products, would still be detected today.

Organophosphate pesticides, which are highly toxic pesticides derived from neurotoxins, have also been widely used on orchards for decades, specifically apple orchards. The two most common organophosphate pesticides used are

- AZM (azinphos-methyl)
- Phosmet

Each have been registered for use since the 1960s and continue to be a prevalent pesticide for orchard growers today. In 2008, in Washington State, where more than half of the country's apples are grown, 80% of orchards reported use of AZM.

Organophosphate pesticides like these tend to adsorb tightly to organic soils and are highly soluble in water. Organophosphates often accumulate in orchard runoff as a result.[8]

SECTION VI

Environmental Testing

Major environmental laboratories typically combine pesticide and herbicide analyses as one testing service. However, pesticides and herbicides are analyzed under separate EPA approved Test Methods, established under RCRA.

EPA Method 8081 (often referred to as Method 8081B to reflect the latest version) is commonly used by laboratories to analyze for organochlorine pesticides in solid and liquid matrices – i.e., soil, sediment, groundwater and surface water samples. EPA Method 8081 uses gas chromatography to measure concentrations of the pesticide compounds listed below.

Compound	CAS Registry No.*
Aldrin	309-00-2
α-BHC	319-84-6
α-BHC	319-85-7
α-BHC (Lindane)	58-89-9
α-BHC	319-86-8
cis-Chlordane	5103-71-9
trans-Chlordane	5103-74-2
Chlordane ~ not otherwise specified (n.o.s.)	587-74-9
Chlorobenzilate	510-15-6
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8
4,4-DDD	72-54-8
4,4-DDE	72-55-9
44-DDT	50-29-3
Diallate	2303-16-4
Dieldrin	60-57-1
Endosulfan I	959-98-8
Endosulfan I	33213-65-9
Endosulfan sulfate	1031-07-8
Endrin	72-20-8
Endrin aldehyde	7421-93-4
Endrin ketone	53494-70-5
Heptachlor	76-44-8
Heptachlor epoxide	1024-57-3,
Hexachlorobenzene	118-74-4
Hexachlorocyclopentadiene	T1-47-4
Isodrin	465-73-6
Methoxychlor	72-43-5
Toxaphene	8001-35-2

*Chemical Abstract Service Registry Number

The Method 8081 analyte list can be expanded to include other compounds including alachlor, captafol, dichloran, and permethrin amongst several others. These compounds have not been fully validated by the EPA and therefore are not typically included in routine testing requests. Refer to the EPA Method 8081B document for a complete list of expanded compounds.

Herbicides are typically analyzed separately under EPA Method 8151A which uses capillary gas chromatography for determining concentrations of certain chlorinated acid herbicides and related compounds in aqueous, soil and waste matrices. Herbicides analyzed via Method 8151A are shown below.

Compound	CAS Registry No.*
2,4-D	94-75-7
2,4-DB	94-82-6
2,4,5-TP (Silvex)	93-72-1
2,4,5-T	93-76-5
Dalapon	75-99-0
Dicamba	1918-00-9
Dichloroprop	120-36-5
Dinoseb	88-85-7
MCPA	94-74-6
MCPP	93-65-2
4-Nitrophenol	100-02-1
Pentachlorophenol	87-86-5

(Table sources: https://www.epa.gov/sites/default/files/2015-12/documents/8081b.pdf; https://www.epa.gov/sites/default/files/2015-12/documents/8151a.pdf)

Like the pesticide analytical method, Method 8151A can be expanded to include other herbicides such as acifluorfen, bentazon, and chloramben. Refer to the EPA Method 8181A document for a complete list of expanded compounds.

Additionally, EPA Method 504.1 is used to determine volatile organic pesticides in water. This method typically targets:[9]

- 1,2,3-Trichloropropane (TCP)
- 1,2-Dibromoethane (EDB)
- 1,2-Dibromo,3-chloropropane (DBCP)

These pesticides were historically used as crop and soil fumigants. EDB was an agricultural fumigant for grains and tree crops, particularly citrus, and DBCP was used primarily as a soil fumigant for many crops including cucumbers, cabbage, soybeans, cotton, pineapples and at orchards. This subset of pesticides has continued to be detected in groundwater near application areas long after their use was banned by the EPA

Lastly, historic crop/orchard operations included use of inorganic substances for agricultural pest control.

Testing for metals (Methods 6010D or 6020B) where there is a history of agricultural use is also a prudent measure. At minimum, the "RCRA 8" metals should be analyzed which include:

- Arsenic
- Barium
- Cadmium
- Chromium
- Lead
- Mercury
- Selenium
- Silver

SECTION VII

Environmental Insurance

Why is environemntal protection important for agricultural clients?

While some insurance policies offer protection for certain types of pollution-related events, many exclude pollution liability coverages. Such policies leave your agriculture clients to fend for themselves and attempt to adhere to the complex environmental regulations and requirements set forth by the government.

Environmental insurance fills the coverage gaps and supplements agriculture coverage by providing your clients with the proper protection. Many Farm policies will limit or exclude pollution coverage to losses at your clients' owned farm locations and only provide 3rd party off-site protection limited only to a sudden and abrupt release or escape of governmentally approved "agricultural chemicals, liquids or gases" which take place within a period no greater than seventy-two (72) hours. A standalone environmental policy from Great American can offer both on and off-site clean-up coverage on a gradual basis (not limited to sudden and abrupt releases) and transportation coverage (including mobile equipment) and includes a broader definition of pollutants which encompasses more than the limited "agricultural chemicals, liquids or gases" covered by a Farm policy.

Exposure Considerations:

**Note, the items below are not an exhaustive list and each potential risk should be evaluated indpendently.*

What is the history of the property? In what era was the property used for agriculture and what crops were cultivated?

What is the future use of the property? Will there be any residential occupancy, gardening?

Were pesticides/herbicides tested for using the appropriate method and list during the site investigation? Were samples collected for metals analysis? What depths and for what media was investigated?

Are there potable wells on the property? Are there public supply wells in proximity?

Are there nearby waterways/surface water bodies which could be impacted from runoff? Pesticide contaminated runoff can result in fish kills, and other serious impacts to aquatic ecosystems.

Was chlordane found to be present? Were any vapor intrusion assessments conducted?

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