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IMPACT OF AGROCHEMICALS ON GROUND WATER

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ABSTRACT

Pesticide use has grown because not only must our exploding population be supplied with food, but crops and food are grown for export to other countries. India has become one of the largest producers of food products in the world, partly owing to our use of modern chemicals (pesticides) to control the insects, weeds, and other organisms that attack food crops. But, as with many things in life, there's a hidden cost to the benefit we get from pesticides. We've learned that pesticides can potentially harm the environment and our own health. Water plays an important role here because it is one of the main ways that pesticides are transported from the areas where they are applied to other locations, where they may cause health problems. Pesticide contamination of groundwater is a subject of national importance because groundwater is used for drinking purpose by about 50 percent of the Nation's population. This especially concerns people living in the agricultural areas where pesticides are most often used, as about 95 percent of that population relies upon groundwater for drinking water. Before the mid-1970s, it was thought that soil acted as a protective filter that stopped pesticides from reaching groundwater. Studies have now shown that this is not the case. Pesticides can reach water-bearing aquifers below ground from applications onto crop fields, seepage of contaminated surface water, accidental spills and leaks, improper disposal, and even through injection waste material into wells.

INTRODUCTION

The term "pesticide" is a composite term that includes all chemicals that are used to kill or control pests. In agriculture, this includes herbicides (weeds), insecticides (insects), fungicides (fungi), nematocides (nematodes), and rodenticides (vertebrate poisons). In areas where intensive monoculture is practiced, pesticides were used as a standard method for pest control. Unfortunately, with the benefits of chemistry have also come disbenefits, some so serious that they now threaten the long-term survival of major ecosystems by disruption of predator-prey relationships and loss of biodiversity. Also, pesticides can have significant human health consequences. Agricultural use of pesticides is a subset of the larger spectrum of industrial chemicals used in modern society. The American Chemical Society database indicates that there were some 13 million chemicals identified in 1993 with some 500 000 new compounds being added annually. The amount of pesticide that migrates from the intended application area is influenced by the par-

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ticular chemical's properties: its propensity for binding to soil, its vapor pressure, its water solubility, and its resistance to being broken down over time. Factors in the soil, such as its texture, its ability to retain water, and the amount of organic matter contained in it, also affect the amount of pesticide that will leave the area. Some pesticides contribute to global warming and the depletion of the ozone layer. Protecting water quality is a top environmental issue (Paningbatan *et al.* 1993).

Pesticides and Water Quality

Using pesticides effectively while maintaining water quality presents an important challenge. As citizens, we must recognize the significant role of pesticides in maintaining a high quality of life. We must acknowledge that the effective production of food and fiber relies on pesticides to control weeds, insects, and plant diseases that interfere with the growth, harvest and market ability of crops. As pest control operators and homeowners - rural as well as urban - we must acknowledge the importance of pesticides in controlling pests in our homes, restaurants, hospitals, parks, ornamental plantings, golf courses, etc. But at the same time we must be aware that pesticide applications can affect water quality. Human and environmental health may be threatened when excessive concentrations of pesticides enter surface or ground water.'Pesticides and water quality' is a complex subject,both technically and politically; but if current and future expectations for community life, agriculture, industry, wildlife and natural habitats are to be met, input from an educated public is essential. A basic knowledge of the subject is important to allow informed participation in the ongoing debate (Hodgson *et al.* 1996)

Ground water is a widely distributed natural resource found beneath the earth's surface. Many people have the mistaken impression that ground water occurs as underground rivers and reservoirs. However, most ground water occurs in tiny voids (spaces) between grains of sand and gravel, between silt and clay, or in cracks and fractures in bedrock.

Geology of Ground Water

The geology of a particular location dictates the depth and volume of ground water. Usable ground water available to supply wells and springs comes from geologic formations called aquifers, which may be shallow (near the earth's surface) or very deep (hundreds of feet below the surface). As a general rule, fresh water aquifers tend to lie 60-300 feet below ground. Aquifers are composed of various materials such as rock, sand, and gravel that reflect local geology. Some consist of unconsolidated (loose) deposits of sand, clay, silt, or gravel containing water in the voids between particles and rock fragments. Other aquifers occur as cracks in bedrock or consolidated (solid) materials such as igneous rock (granite, basalt), sedimentary rock (limestone, siltstone, sandstone), or metamorphic rock (slate). Aquifers are characterized as either confined or unconfined. Confined aquifers lie below a layer of less permeable clay or rock-a confining layer-which greatly slows the vertical movement of water. The water in confined aquifers can be recharged from water that moves into the water-bearing zone from distant areas where there are no confining layers. Unconfined aquifers do not have a confining layer and are 'open' to water moving down from surfaces directly above. The water surface of unconfined aquifers-the water table-fluctuates with changes in atmospheric pressure, rainfall and other factors. Unconfined, unconsolidated aquifers are particularly vulnerable to contamination because, typically, they are quite shallow and surface water can infiltrate quickly down to the water table (ground water) in certain soils. (Damalas *et al*. 2011).

Downward Movement of Water

Between top soil and water-saturated soils, voids of unconsolidated materials fill with water and air, forming the vadose (unsaturated) zone. The portion of the vadose zone near the soil surface is where plants root, vegetation decays, and animals burrow; it is in this area that most terrestrial plants and soil organisms reside. The lower portion of the vadose zone hosts less biological activity. Precipitation either runs off sloping land or infiltrates only the upper few inches of soil, then percolates downward and permeates the upper vadose zone. As water enters soil voids, a variety of physical processes pull it into the vadose zone, replacing air. The water table is defined as the area that separates the vadose and saturated zones. Water below the water table is ground water. All soils can store water in voids. A soil's ability to store and transfer water downward in saturated or unsaturated conditions is a function of numerous interrelated processes and features. For example, the nature of soil particulates and the way they aggregate influence features such as porosity and how water is attracted to soils. Soils with small voids can store more water than those with larger voids. Under saturated flow, porosity and the pull of gravity greatly influence water movement. Under unsaturated conditions, attraction of water to soil surfaces (matrix potential), movement along a maze-like flow path, and very small pores (capillaries) influence water movement. Natural ground water movement is often (but not always) in the direction defined by local topography. Horizontal flow of ground water generally is slow and is measured in inches per day or feet per year, depending on the porosity and the permeability of the materials making up the aquifer. (Medina 1996)

In most cases, a period of a few months to several years is required for a pesticide to leach considerable distances through soil to reach ground water. Therefore, a pesticide generally needs to be both persistent and mobile to reach most aquifers. The extent of pesticide movement through soil depends on the degree of interaction between the pesticide and soil particles, soil microorganisms, and weather. The amount of pesticide that will reach low soil depths varies dramatically with slight environmental fluctuations, making estimation difficult. A judgment can be made on the overall likelihood of ground water contamination by comparing the mobility and persistence of a chemical to those of similar pesticides previously detected in ground water at multiple use sites. Many factors affecting the environmental fate of a pesticide are not well understood. Site-specific behavior of pesticides in soils cannot be predicted unless actual field data are available for comparison. A Health Advisory Level (HAL) is considered the maximum level of a drinking water contaminant, in milligrams per liter (parts per million, or ppm) or micro- grams per liter (parts per billion, or ppb), that would not be expected to cause noncarcinogenic health risks over a given duration of exposure.

Risk assessment of pesticides for water quality concerns

Understanding the toxicological properties of a drinking water contaminant is necessary when calculating a health advisory. Toxicological profiles for pesticides generally are derived from animal tests because human testing is not possible. Data from human epidemiological studies can be used, but such data generally are unavailable. Use of pesticides in developing countries is extremely variable, from nil in large parts of Africa, to extremely heavy dosage in intensive agricultural areas of Brazil and plantations of Central America. In their review of the limited research literature on pesticide use and impacts in Africa, Calamari and Naeve (1994) conclude that, "The concentrations found in various aquatic compartments, with few exceptions are lower than in other parts of the world, in particular in developed countries which have a longer history of high pesticide consumption and intense use. Generally, the coastal waters, sediments and biota are less contaminated than inland water environmental compartments, with the exception of a few hot spots." The effects of past and present land-use practices may take decades to become apparent in groundwater. When weighing management decisions for protection of groundwater quality, it is important to consider the time lag between application of pesticides and fertilizers to the land and arrival of the chemicals at a well. This time lag generally decreases with increasing aquifer permeability and with decreasing depth to water. In response to reductions in chemical applications to the land, the quality of shallow groundwater will improve before the quality of deep groundwater, which could take decades. (Castaneda *et al*. 1996)

Pesticides are mostly modern chemicals. There are many hundreds of these compounds, and extensive tests and studies of their effect on humans have not been completed. That leads us to ask just how concerned we should be about their presence in our drinking water. Certainly it would be wise to treat pesticides as potentially dangerous and, thus, to handle them with care. We can say they pose a potential danger if they are consumed in large quantities, but, as any experienced scientist knows, you cannot draw factual conclusions unless scientific tests have been done. Some pesticides have had a designated Maximum Contaminant Limit (MCL) in drinking water set by the U.S. Environmental Protection Agency (EPA), but many have not. Also, the effect of combining more than one pesticide in drinking water might be different than the effects of each individual pesticide alone. It is another situation where we don't have sufficient scientific data to draw reliable conclusions (Helling *et al.* 1996).

Protection of ground and surface water quality is critical to economic viability, as well as human health and environmental quality. Although pesticides are essential in the production of an adequate, economical food supply, rural (agricultural) as well as urban uses loom as possible sources of water contamination. Detection of pesticides in water aroused public interest in the environmental impact of agricultural chemicals; and the resulting heightened concern is reflected in strict legislation which impacts the pesticide industry significantly.

CONCLUSIONS

In the interest of minimizing risks associated with pesticides, significant public resources have been allocated for the development and implementation of rational, pesticide use policies based on solid scientific evidence. Compliance involves extensive, detailed, expensive laboratory research and field studies to determine the behavior and environmental fate of pesticides-that is, in deriving the solid scientific evidence and it follows that manufacturers must commit significant financial resources to product development en route to the marketplace. A pesticide's route and rate of entry into the environment, as well as its degradation characteristics, are key to understanding and predicting its potential impact on surface and ground water. Preregistration research data also play a significant role in determining use pattern and hazard statement language for the pesticide label. Research findings also influence the stringency of post-registration monitoring program.

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