

ORGANIC POLLUTION OF GROUND WATER: ITS PREVALENCE, IMPLICATION AND CONTROL

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ABSTRACT

It is becoming increasingly apparent that pollution of ground water by synthetic organic chemicals is potentially a very serious problem that must be addressed if the quality of our ground-water resource is to be protected. There has been only a very limited effort to assess the extent and probable impact of organic pollutants on ground water from such sources as spills, industrial waste disposal, municipal landfills, septic systems, artificial recharge, and land application of wastewater. While most reported cases of organic ground water pollution have been limited to those relatively intense pollution events, low-level insidious pollution of ground water by organic chemicals is just beginning to be recognized as an equally important aspect of the overall problem. There is a pressing need to establish control criteria for these as well as other sources of organic pollution that will not only permit reasonable utilization of the subsurface as a pollution receptor but will also adequately protect ground-water quality.

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INTRODUCTION

In the last 30 years this country has undergone a far-reaching chemical revolution. We have become chemical addicts in the sense that virtually every facet of American Society is associated in some way with synthetic organic chemicals. Many of these chemicals have brought us tremendous benefits but at the same time others pose a potentially serious threat to the quality of our environment, particularly with respect to the detrimental health effects resulting from long-term exposure to a seemingly infinite number of organic compounds.

Like many of the other aspects of ground water which have been ignored in the past, there has been only a very limited effort to assess the probable impact on ground-water quality of these synthetic organic pollutants. This indifference has resulted because of first, a preoccupation with more readily apparent and pressing problems of surface water pollution; second, a general lack of knowledge concerning ground water and the importance of this resource on the part of the public and responsible political entities; and third, a false sense of security concerning ground-water quality based on an inflated concept of the degree of

protection afforded ground water by the overlying soil mantle. Now, however, it is becoming increasingly clear that serious and widespread pollution of ground water by organic chemicals is a very real possibility that must be addressed if the quality of our valuable ground-water resource is to be protected.

The potential for pollution of ground water by organic chemicals is considerable in the highly industrialized U.S. because many activities of the growing and affluent population are causing the release of a vast array of organic pollutants into the soil profile where they are subject to transport by infiltrating water through the unsaturated zone and into underlying ground water. Ironically, the efforts to decrease pollution of air and surface waters are actually increasing the potential for organic ground water pollution by causing a much more intensive use of the soil profile as a receptor for waste materials.

In contrast to most naturally occurring organics, the synthetic organic pollutants are of particular concern in regard to the potential pollution of ground water because many of the synthetics are relatively intractable to degradation in the environment. Hence, they are likely to effectively resist the intense biochemical degradation process in the soil zone and be transported intact through the soil profile and into underlying ground water. Also, many of these compounds exhibit some form of toxicity to higher animals, but more important there is serious concern about the long-term health effects from continual ingestion of water containing even very low concentrations of such organic materials.

## DISCUSSION

### Sources of Contamination

According to the recently completed inventory mandated by the Toxic Substances Control Act, there are over 40,000 different organic chemicals presently in commerce with hundreds of new compounds being added each year. Obviously not all of these compounds are toxic nor do all have the same potential for ground-water contamination. In trying to assess this potential, a number of activities can be singled out based on both documented reports and a consensus of those working in the field as being the most likely sources of organic ground-water contamination. Two such activities which have the potential for creating relatively high levels of organic pollution are spills and leaks that occur during the manufacturing and transportation process and second, improperly operated industrial waste disposal sites. Of equal importance are those activities which have the potential for generating more widespread but lower level organic pollution such as municipal landfills, septic systems, recycling of wastewater by artificial recharge, and land application of wastewater. These six major potential sources of organic pollution of ground water are discussed briefly below; while this information is not exhaustive in terms of including all possible sources of organic ground-water pollution, it does illustrate some of the difficulties encountered in trying to assess this problem.

Spills and Leaks. One of the first areas of concern are the inevitable spills and leaks which seem to be a natural consequence of the tremendous quantities of organic chemicals that are transported, stored, and utilized in various industrial and commercial activities throughout the Nation. Because of the magnitude of these operations, it is inevitable that leaks will occur in pipelines and storage vessels, and spills from accidents involving transport vehicles or simply improper handling will often result in the release of organic compounds, sometimes in massive quantities, into the soil profile.

In actual fact, leaks and spills, particularly of petroleum products, probably lead all other sources in reported cases of organic pollution of ground water. Cases range from gross pollution, such as that which occurred when an estimated one million l. of gasoline leaked from a pipeline into an aquifer in Los Angeles, to much less intensive pollution incidents such as the increasing number of reported leaks from underground gasoline storage tanks.

Industrial Waste Disposal. A second area of high priority concern are industrial wastes which constitute one of the potentially largest and most diverse sources of ground-water pollution. It has been estimated that industry generates about 24 trillion l. of wastewater requiring some type of treatment prior to discharge along with some 450 million metric tons of solid wastes each year. Much of this industrial waste undergoes onsite treatment and disposal and is, therefore, outside of public scrutiny. Despite the fact that the environmental impact of these wastes is almost impossible to assess, there is a tremendous potential for widespread ground-water pollution by virtue of the magnitude of the volumes involved.

In particular, those processes which involve the production or transformation of organic materials may produce a concentrated waste stream that is often highly toxic and by its very nature difficult to treat. These solid and liquid waste streams are often subjected to some type of treatment process which involves ultimate disposal to the soil profile through surface impoundment, land filling, or deep well injection. The treatment process can range from little or no treatment at all to one of the more advanced methods, but more often than not it involves whatever happens to be convenient or economically practical at the time. Improper or inadequate treatment often becomes evident through some sort of environmental disaster years later in which hazardous organic wastes move slowly through the subsurface resulting in widespread ground-water pollution.

In an attempt to assess the ground-water pollution potential from subsurface migration of hazardous constituents at industrial land-disposal sites, a recent investigation of a number of these facilities revealed that 85% of the sites sampled showed the presence of organic compounds above background levels, thus, indicating that organic wastes can migrate significant distances from typical landfills and liquid-waste disposal lagoons. Essentially all of the waste disposal facilities inspected and receiving large quantities of industrial wastes were sited, designed,

and managed in a manner similar to those where the migration of hazardous substances was established by sampling. Based on this study as well as others, the conclusion is that organic ground-water contamination at industrial waste disposal sites is widespread and that present land disposal practices pose a serious threat to ground-water quality.

Municipal Landfills. It is estimated that municipal landfills receive approximately 200 million metric tons of solid wastes each year much of which is disposed in close proximity to areas of high population densities. Like their industrial counterparts, municipal waste disposal sites produce huge volumes of leachate containing a wide array of organic compounds. These active landfills, as well as numerous abandoned sites, comprise a very significant potential source of pollution of ground water by organic chemicals.

Water moving through municipal landfills will usually leach very high concentrations of organic matter from freshly deposited refuse. However, the initial leachate appears to be mostly comprised of relatively labile organic substances which are readily attenuated by bio-chemical and physical processes in the soil profile. However, the less labile organic compounds which are the more persistent in the subsurface, and which are more likely to be leached slowly from the refuse after the initial stage of extensive leaching, appear to be of more pressing concern in regard to ground-water pollution. This implies the potential for long-term insidious pollution of ground water from slowly decaying domestic and commercial products in municipal landfills which in turn can serve as reservoirs feeding low levels of potentially harmful organic pollutants into aquifers for many years, even after the landfills have been closed and forgotten.

Septic Systems. Another area of potential concern are the 17 million septic systems currently in use in the U.S., which it's estimated release about three trillion l. of wastewater per year to the soil profile. Although they are one of the most frequently reported sources of ground-water pollution, there are currently very few documented cases of organic ground-water contamination from septic systems, particularly from those which are properly designed and operated. This undoubtedly reflects the fact that most of the organic matter in the septic tank effluent is readily removed by sorption and degradation in the aerobic soil environment.

Septic systems cannot, however, be dismissed as potential sources of organic chemical pollution of ground water as their effluents are likely to contain a variety of synthetic organic chemicals originating from many household products such as pharmaceuticals, disinfectants, deodorants, polishing agents, cleaning materials, cosmetics, paint, and pesticide products. In addition, low molecular weight chlorinated hydrocarbons may be present as the result of septic tank cleaners or reactions between bleaching agents and organic matter present in household wastewater. Although the concentrations of these compounds are not likely to approach the levels of synthetic organics from other sources, their potential intractability to microbial

degradation and possible adverse health effects when ingested, require that attention be given to their presence and fate.

Artificial Recharge of Wastewater. Increasing attention is now being given to the possible use of reclaimed wastewater for direct recharge of ground water reservoirs in order to meet future water supply needs. Since this practice involves the potential introduction of residual contaminants directly into ground water, there are a number of important public health aspects of artificial recharge that must be clarified before this method can be universally adopted.

In an attempt to address these questions, there are a number of projects currently in progress to evaluate the movement and ultimate fate of residual organics introduced with reclaimed wastewater. The early data resulting from these projects indicate that in some instances the subsurface may provide a suitable receptor for the attenuation of residual organics. In other cases, however, the degree of attenuation depends on a number of complex physical, chemical and biological interactions which need to be better defined in order to more effectively design and operate these systems to protect ground-water quality. Before artificial recharge can become a viable means of water reuse, a great deal more research is needed to obtain a better understanding of the movement and fate of organics in the subsurface environment.

Land Application of Wastewater. Land application is a rapidly growing method of disposal of wastewater, and the number of such systems funded during the next decade is expected to increase dramatically because of current policy favoring this treatment method. This policy has been adopted primarily because, based on a number of EPA studies, properly designed and operated land application systems appear capable of providing a relatively high level of treatment of domestic wastewater, provide a reduction in the quantity of wastewater discharged to surface waters, and are usually less costly and less energy intensive than other means of treatment. Obviously, however, this treatment method entails a higher potential for pollution of ground water by wastewater constituents, including organic chemicals, than do the conventional treatment systems.

Of greatest concern in regard to the potential pollution of ground water by organics are rapid infiltration systems which utilize application rates of up to 125 m. of water per year, and those irrigation systems where the quantity of applied wastewater is far in excess of crop needs. If the wastewater being treated by such systems contains an industrial component comprised partly of synthetic organics, the treatment process is likely to result in the release of significant quantities of relatively intractable organic chemicals into the soil profile which, under conditions of high water flux, favors transport of pollutants directly into the underlying ground water. Once again, there needs to be a better definition of this pollution potential so that land application systems can be more effectively designed and operated to protect ground-water quality.

## CONCLUSIONS

Documented reports of organic ground-water pollution from these and other sources are becoming more numerous, due not only to an increasing frequency of such incidents, but also to the availability of improved analytical techniques as well as an increasing awareness of this problem by the scientific and technical community. Nevertheless, the currently available information is far from that needed to accurately assess either the present extent or future potential of this pollution problem. Most reported cases of organic ground-water pollution to date have been limited to those rather intense pollution events in which the presence of pollutants was detected because of alteration of some physical property, such as taste, odor, or color of the affected water. Low-level, insidious pollution of ground water by organic chemicals is just beginning to come under the scrutiny of ground-water research because, in addition to being a recently recognized problem, it requires especially difficult experimental techniques and sophisticated analytical procedures.

Obviously, the prudent course of action is instigating control of these potential sources of organic pollution, rather than attempting to clean up aquifers after organic pollution has occurred. There is a pressing need to establish control criteria that will adequately protect ground-water quality and yet permit reasonable utilization of the subsurface as a pollutant receptor. A great deal more research is needed to develop definitive information concerning the transport and transformation of organic pollutants in the subsurface in order to provide a firm basis on which to establish such control criteria.