WATER POLLUTION BY AGRICULTURE AND OTHER RURAL USES

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Summary

Contemporary agriculture heavily depended on chemical substances in order to achieve the “Green Revolution”. Natural organic matter or compost was rapidly replaced by chemical fertilizers, and pesticides were widely used to secure the highest yield of desired crops. Pesticides are sprayed in paddy fields or crop fields for agricultural activities worldwide. In general, only a small part of the pesticide is effectively applied to the farm products; most of it enters the soil.

As a consequence of their persistency and bioaccumulation properties, certain pesticides, which are able to accumulate in higher organisms (even in human beings),

have caused serious problems to ecosystems. Production and use of these pesticides have therefore been restricted in many countries. The properties of most pesticides have been changed so that they degrade in the environment.

During the production process of agricultural chemicals, trace amounts of dioxins are also produced, and these can remain in the final products. The dioxin group is not volatile and is poorly soluble; furthermore, they are very persistent in environment. As a result, they are adsorbed to particulate matter and finally settle in soil or sediment of rivers, lakes, or seas.

Nitrate is a relatively non-toxic substance which occurs naturally as part of the nitrogen cycle. Once ingested, however, nitrate is reduced to nitrite by bacterial activities. In the blood, nitrite oxidizes iron in the hemoglobin of red blood cells to form methaemoglobin, which lacks haemoglobin's oxygen-carrying ability.

Many water sources, at which high concentration of nitrate and nitrite have been reported, are often surrounded by orchards or vegetable farms, which implies water contamination by agricultural fertilizers. If nitrate (and nitrite) nitrogen levels of source water exceed 10 mg L^{-1}, some treatment process must be provided before the distribution of drinking water. However, no simple method to remove nitrate has been developed. Usually, contaminated water is mixed with other non-polluted water sources before being supplied for drinking purpose.

1. Introduction

Contemporary agriculture heavily depended on chemical substances in order to achieve the “Green Revolution”. Natural organic matter or compost was rapidly replaced by chemical fertilizers, and pesticides were widely used to secure the highest yield of desired crops. Pesticides are sprayed in paddy fields or crop fields for agricultural activities worldwide. Most of the pesticide applied is degraded in agricultural fields, if it is applied properly, and does not cause serious water pollution. In general, however, only a small part of the pesticide is effectively applied to the farm products; most of it enters the soil. In addition, some pesticide scatters during spraying and is carried outside the fields.

In recent years, more attention has been paid to environmental pollution caused by chemical substances, and their adverse effects on the environment, including those on human health, have been much discussed. Pesticides and other agricultural chemicals are different from other chemicals because they are used in open areas and in large quantity, and are used only in certain seasons. Therefore, environmental pollution by agricultural chemicals needs to be carefully considered.

The behavior of pesticides in the environment can be summarized by their volatility, solubility in water, partition coefficient in water and air, adsorption, biodegradation and concentration. These characteristics are so diverse that the pesticides sprayed on the fields move between the compartments of air, water and soil, and thus the fates of the pesticides are determined by their particular properties.

Chemical fertilizers also affect the environment. Excessive application causes eutrophication of environmental water, and can cause nitrate contamination, which is a health hazard in drinking water. Several measures are proposed to control and reduce nitrogen level in environmental water.

2. Pesticides

2.1. Behavior of pesticides in the atmosphere

A part of the pesticides which falls on the soil, or which has been directly applied to the soil, evaporates and passes into the atmosphere. As a result, a certain amount is transferred into the atmosphere as gas or in a form attached to suspended particulates. In real terms, however, the pesticides in the atmosphere are diffused and diluted by various atmospheric phenomena such as movement of air masses and fluctuation of wind direction. Pesticide pollution in the air is, therefore, usually a local and temporary phenomenon. Although the pollution level is high immediately after spray of pesticides, the level usually drops in a few days. Air pollution may continue for a longer period if a large amount of pesticides is sprayed over wide areas.

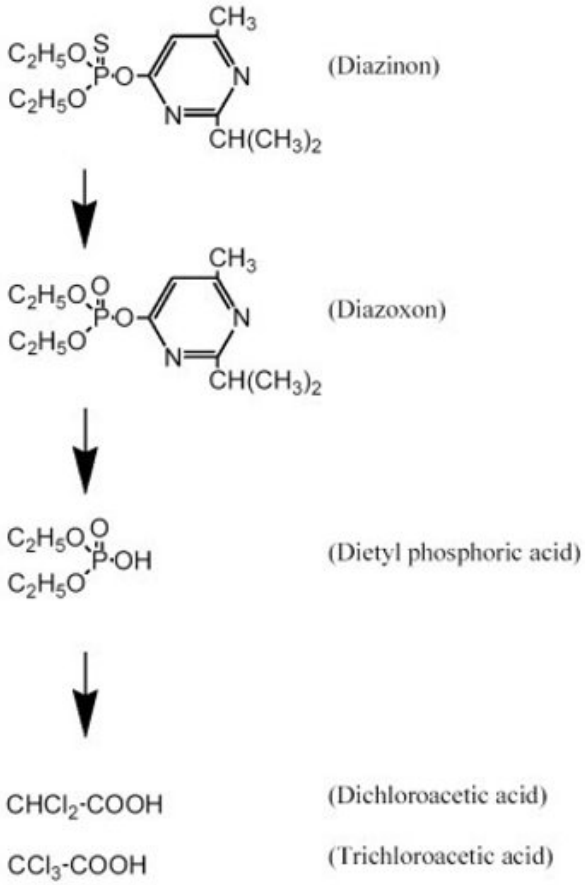

Figure 1. Degradation of diazinon by photolysis or chlorination

Pesticides in the atmosphere are slammed down with the falling rain and pass into the soil and thus, the water system. Not only falling rain but also photochemical reactions

contribute significantly to the reduction of the pesticides in the atmosphere. Photolysis of pesticides is essentially the same as the photochemical reaction in organic chemistry. For example, an organic phosphorus insecticide, parathion, is known to be photo-oxidated from a thiono compound (P=S) to an oxon derivative (P=S double bond is replaced by P=O double bond), as shown in Figure 1, by ultraviolet irradiation. In addition, isomerization of the chemical to thiol derivative (P-S-) is also recognized. Some of these photolytic products have stronger residual capability and toxicity than the original chemical compounds. Therefore, attention should also be paid to the behavior of these photolytic products.

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Biographical Sketches

Yuichi Fushiwaki is a Senior Researcher at Kanagawa Prefectural Institute of Public Health, where he has been in office since 1999. He graduated from the Faculty of Pharmaceutical Sciences of Science University of Tokyo in 1974. Then, he worked for Kanagawa Prefecture and Kanagawa Environmental Research Center from 1974 and 1999, respectively. In the meantime, he obtained a Ph.D. in Engineering from Yokohama National University in 1994. His field of work includes evaluation of environmental toxicology in river water and atmosphere using bioassay, and the behavior and environmental pollution of pesticides.

He has given lectures for the Faculty of Engineering, Yokohama National University and Faculty of Environmental Science, Tsukuba University as a part-time lecturer since 1994 and 2002, respectively. He is also a visiting researcher of the National Institute for Environmental Studies.

Yasumoto Magara is Professor of Engineering at Hokkaido University, where he has been on faculty since 1997. He was admitted to Hokkaido University in 1960 and received the degree of Bachelor of Engineering in Sanitary Engineering in 1964 and Master of Engineering in 1966. After working for the same university for 4 years, he moved to the National Institute of Public Health in 1970. He served as the Director of the Institute since 1984 for Department of Sanitary Engineering, then Department of Water Supply Engineering. In the meantime, he also obtained a Ph.D. in Engineering from Hokkaido University in 1979 and was conferred an Honorary Doctoral Degree in Engineering from Chiangmai University in 1994. Since 1964, his research subjects have been in environmental engineering and have included advanced water purification for drinking water, control of hazardous chemicals in drinking water, planning and treatment of domestic waste including human excreta, management of ambient water quality, and mechanisms of biological wastewater treatment system performance. He has also been a member of governmental deliberation councils for several ministries and agencies including Ministry of Health and Welfare, Ministry of Education, Environmental Agency, and National Land Agency. He performs international activities with JICA (Japan International Cooperation Agency) and World Health Organization. As for academic fields, he plays a pivotal role in many associations and societies, and has been Chairman of Japan Society on Water Environment.

Professor Magara has written and edited books on analysis and assessment of drinking water. He has been the author or co-author of more than 100 research articles.