Zeo-Agriculture
Use of Natural Zeolites in Agriculture and Aquaculture

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FUTURE PERSPECTIVES FOR NATURAL ZEOLITES IN AGRICULTURE AND AQUACULTURE

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Zeo-Agriculture '82, the Conference on which this volume is based, was held at an early stage in the use of zeolite minerals in agriculture. Interestingly, certain worldwide studies have suggested that the dietary use of zeolites can significantly improve the growth rate of poultry and swine and that their amendment to low-clay soils can, under certain circumstances, increase crop production. On the other hand, similar studies have found little or no improvement when the same materials were used in the same animal or soil experiments. The Conference papers contained in this volume reflect this apparently contradictory situation, but they excite one's interest in the potential value of natural zeolites in agriculture. It is clear, however, that considerable work remains before our understanding of the role of zeolite materials in agricultural systems is clarified. Zeo-Agriculture '82, therefore, served as a much needed forum where agronomists, plant scientists, animal nutritionists, aquaculturalists, and agricultural engineers met and exchanged information on their zeolite/agriculture experiments and where they were able to interact with zeolite experts from the geological, mining, and chemical communities. Such interaction seemed beneficial to all participants, with the agricultural scientists improving their familiarity with zeolite ion-exchange and adsorption capabilities, and the zeolite researchers increasing their appreciation of the complexities and uncertainties of agricultural investigations.

Throughout the Conference a number of problems were recognized in this fledgling, interdisciplinary field and were discussed formally from the podium and informally in the hallways and at various social functions. These problems ranged from ascertaining the major zeo-agricultural research areas currently not being investigated to possible adverse effects of sustained use of zeolites in soil and animal regimes. Questions were raised that ranged from what are the possible sources of funding for future zeo-agricultural research to why zeolites seem to perform better in countries having lower agricultural productivity than the United States. In addition, a major, overriding question emerged concerning the need for greatly improved characterization of the zeolite starting materials used by agricultural investigators. Without the needed characterization, the optimum use of zeolites in agriculture is unlikely to be achieved. These and other questions directed at the future impact of zeo-agriculture on food production in the United States and other
countries were addressed candidly during the final technical session of the Conference, as part of a Round-Table Discussion among panelists representing the natural zeolite suppliers, the U.S. Department of Agriculture, the international zeolite community, and researchers from the plant sciences, agricultural engineering, animal nutrition, and aquaculture.

Two closely related problems became apparent from these discussions: First, many agricultural scientists working with zeolite materials are poorly informed on the chemistry, structure, and physical properties of the very materials they are using in their experiments. Their lack of knowledge of the similarities and differences among the several natural zeolite species showing promise for agricultural usage has led to less than optimal experimental designs. For example, the lack of knowledge of the inherent chemical and mineralogical differences (and therefore, e.g., of ion-exchange reactivity) that might exist from deposit to deposit or even within a single deposit is particularly troublesome. Second, many geological and chemical scientists, experts on zeolites in their own right, seem to be poorly informed on the profound genetic and physiological variabilities that exist from animal to animal or from plant to plant, or of the chemical complexities of a plant-soil system or within an animal’s digestive tract. Considering these deficiencies, it is no wonder that many of the zeo-agricultural results obtained to date lack agreement. It became apparent that future zeo-agricultural successes will require an interdisciplinary approach to the problem, with the chemist, mineralogist, and agriculturalist working hand in hand. The recognition of this desired arrangement was probably one of the major accomplishments of the Conference.

In spite of these problems, some zeo-agricultural research has been relatively successful. For example, the use of zeolites as ammonium ion exchangers for recirculating fish-hatchery waters and in fish-culture systems has allowed more fish to be raised in the same volume of water than in the past, thereby reducing the overall energy requirements of the system and increasing biomass production. Engineering design for such processes, however, still needs fine tuning. Although additional research is also necessary on the zeolitic removal of ammonia from brackish and saline waters, it seems that this alternative to biofiltration will contribute measurably to increased aquatic protein production. Similarly, the harnessing of the hydration-dehydration phenomena of certain zeolites in solar refrigeration systems appears to be close to commercial reality and should result in increased storage capabilities for fresh fruit, vegetables, fish, and dairy products in many developing nations where electricity supply is unreliable or not available.

The effect of dietary zeolites on the metabolism, health, and performance of meat animals seems to hold considerable promise for the future; however, the mixed results of many experiments carried out in this country suggest that additional research is required to assess the impact of these materials on the microbial population of the animal gut, especially those of swine and ruminants. The cation-exchange and -release mechanisms for ammonium and other elements by zeolites in the gastrointestinal system of animals has not been delineated satisfactorily, nor has been the effect of these materials on parasite growth and expulsion. These areas are greatly in need of additional research. In all of the swine, poultry, and ruminant studies conducted to date, no adverse effects of dietary zeolites have been found on the health or vitality of the animals nor on the quality of the meat, eggs, or dairy products obtained from them. On the contrary, scours and other intestinal diseases appear to have been alleviated by their use, and mortality rates have decreased.

Zeolites have been and probably will continue to be used in Japan and in certain
other parts of the world as soil conditioners for improving gas exchange, moisture retentivity, and cation-exchange capacity. They also show some potential for improving the fertility of sandy soils in the United States where nutrients are easily lost through leaching or where slow-release nitrogen or potassium is needed, and for protecting plants from nitrogen burn caused by over-fertilization with urea or ammonium salts. Transportation costs may preclude widespread amendment use of zeolites for field crops, such as corn, sorghum, and wheat, but banded applications in the production of high-value crops, such as vegetables, flowers, and fruit, may be feasible. Recent successes of Bulgarian researchers with artificial soils consisting of clinoptilolite, peat, and vermiculite—zeoponics, as it were—suggests that one attractive application of zeolites may be in greenhouse horticulture.

Reactions between zeolites and commercial fertilizers need further investigation. Depending on the particular soil environment, zeolites may be used to facilitate nutrient availability, such as in certain soils of the western United States where iron and zinc deficiencies exist. On the other hand, care must be taken not to tie up nutrient elements so strongly that they are prevented from movement into the soil solution and eventual uptake by the plant. Certain zeolites rich in exchangeable sodium may increase soil salinity, releasing Na\(^+\) as K\(^+\) and NH\(_4\)\(^+\) are taken up by the zeolite. Thus, additional research by soil chemists on both the short-term and long-term effects of amended zeolites is desirable.

Funding for zeo-agricultural work is a general problem. Because of the inherent nonpatentable nature of many zeo-agricultural applications, some industrial organizations are reluctant to disclose experimental results which they consider proprietary in nature. Even though this is an understandable attitude, it has inhibited broad exchange of research findings and probably slowed zeo-agricultural development. On the other hand, research proposals to government agencies have all too often fallen into the cracks between budgetary programs, with the geological and mining organizations saying that the proposed work really is agriculturally oriented and therefore should be supported, for example, by the U.S. Department of Agriculture. At the same time, agricultural organizations have maintained that the geologists should be supporting research on these mineral materials. The agriculturalists themselves heretofore have "bootlegged" many of their zeo-agricultural studies or have relied solely on short-term funding from producer companies. In general, they have not been overly aggressive in developing broader based sources of funding. Perhaps this situation will change in the future. Certainly opportunities exist to relate zeo-agricultural research, for example, to one of the three principal research missions of U.S.D.A., namely, (1) plant productivity, (2) animal productivity, and (3) improved cultural and crop practice.

A final question raised at the Conference and illustrated by several papers contained in this volume is, perhaps, the most perplexing of all. Despite the fact that natural zeolites appear to have the greatest marginal benefit in areas where agricultural productivity is not as highly advanced as in the United States, most of the discussion at the Zeo-Agriculture '82 Conference concerned their use in the developed nations, rather than in the highly populated, poorer nations of the world. The interlinked developing-country problems of low soil fertility, limited animal protein supply, rampant poverty, and rapidly expanding populations suggest that increased zeo-agricultural research in these countries or research designed specifically for their needs holds real promise. There is every reason to expect that in the volcanic regions and other appropriate geological settings of many developing nations mineable deposits of clinoptilolite and other natural zeolites will be found.