Commission of the European Communities

Phosphorus in Sewage Sludge and Animal Waste Slurries

Proceedings of the EEC Seminar organized jointly by the CEC and the Institute for Soil Fertility, Haren (Gr.) and held in Groningen, Netherlands on June 12 and 13, 1980

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PREFACE

Whilst phosphorus is well known as a valuable nutrient encouraging plant growth, excessive quantities resulting from the disposal of human and animal wastes at high rates can result in adverse agricultural effects and environmental nuisance in polluting rivers etc.

The effects of phosphorus have been considered by those studying the disposal of Effluents and Wastes from Agriculture and by those involved in the Concerted Action project on research into the Treatment and Use of Sewage Sludge. Since many of the aspects of phosphorus utilisation and disposal are common to both agricultural and human waste disposal it was decided to hold a joint seminar in Haren, Netherlands in June 1980.

This book contains the papers submitted to the meeting and summaries of the discussion.

The conference was divided into 4 sessions. The first was in the form of an introduction and devoted to the general aspects of the phosphorus cycle in soils and included the binding capacity and analytical problems. The second was devoted to the phosphorus content of sludges and slurries with reference to variations in the phosphorus content of sludges and the effects of feedstuffs on animal slurries. The third session dealt with the phosphorus value of sludges and slurries and included references to field trials and laboratory studies. The fourth and final session covered the accumulation and leaching of phosphorus after landspreading on a wide variety of soils.

The seminar was most effective in bringing together the various aspects of phosphorus utilisation and disposal and the variations in the phosphorus from the different sources. It is hoped that the scientific reports in this volume will encourage the maximum use of the nutrient value of phosphorus whilst avoiding any harm from excessive application.

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OPENING REMARKS

T.W.G. Hucker *(UK)*

Good morning ladies and gentlemen. This seminar on Phosphorus and Animal Wastes is a joint meeting of the two Working Parties on the utilisation of sewage sludge - Working Party 4, dealing with manurial value and Working Party 5, dealing with environmental effects, together with the Effluents from Livestock Research Programme. We have always felt that there is much common ground in waste disposal as a whole and this is our first opportunity to get together.

Dr. Sluijsmans, who is the Director of the Institute for Soil Fertility at Haren, would like to say a few words of welcome.

C.M.J. Sluijsmans *(Netherlands)*

Thank you Mr. Hucker. Ladies and gentlemen, the Staff and Management of the Institute for Soil Fertility appreciate very much that the European Commission has decided to organise this meeting here in Groningen. We are very pleased to see so many of you here to participate in the discussions. It means that the work that is done at our Institute on sewage sludge and other wastes, is recognised as providing a significant contribution to the knowledge we are all aiming at. It appears that our representatives in the various working groups make a favourable impression on their colleagues.

I would just like to say a few words about our Institute. You have seen that we have a modern building in which to work. We moved in in 1968 but the Institute was founded in 1890. In another ten years there might well be a good reason for another international conference to celebrate our centenary.

The staff of the Institute comprises about 120 people, including 30 to 35 university graduates. At least 10 of these research workers are engaged full or part time on waste problems. The Institute is spending 15% to 20% of its budget on waste problems - sewage sludge, compost, dredged sludge and animal wastes. We anticipate that this level will continue for the next five years with the accent on the effect of those materials on crop quality with regard to human and animal health, and on the effects on soil quality and ground and surface water.

Today and tomorrow the subject of your sessions will be phosphorus. Thanks to the widespread use of phosphate fertilisers for many years in this country, a temporary halt in phosphate application would not have a disastrous consequence. From long term experiments we know that omitting phosphate, even for a period of five to ten years, would not result in a yield depression of more than 10% for potatoes and 5% for cereals. Compared with nitrogen, phosphate can be regarded as much less important in this country. Nevertheless, together with our colleagues from abroad, we are continuing to study the remaining questions with regard to phosphate. It is our task to answer such questions as whether phosphate is leached to the surface water and how much time it takes to do this in different soil profiles; the run-off of phosphate; the availability in different fertilisers and wastes, and the effect of granulation of fertilisers and wastes, particularly understanding the effect of granulation. We must understand why one method of analysis of soil phosphate is better than another; why is analysis of phosphate in acid extract, for our grassland, better than in water? Why is water better than acid on arable land? We must discover why phosphate in one sewage works better than another.

At our Institute we are happy to have so many colleagues from elsewhere who are actively working on these problems and who are willing to transmit their knowledge to us. You are all very welcome from that point of view also.

<u>T.W.G. Hucker</u>

Thank you Dr. Sluijsmans for those words of welcome and introduction. Having travelled the length of Holland in the past week I can say that the Institute for Soil Fertility can be seen to be doing an excellent job - the soil is certainly producing excellent crops.

We all appreciate the atmosphere in which we have been received here and we are looking forward to the next two days.

SESSION I

GENERAL ASPECTS OF THE PHOSPHORUS CYCLE IN SOILS

Chairman: T.W.G. Hucker

PHOSPHORUS IN RELATION TO WATER QUALITY: GREAT LAKES WATER QUALITY AND THE PHOSPHORUS REMOVAL PROGRAMME

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ABSTRACT

Phosphorus is the main factor contributing to eutrophication in the Great Lakes. Joint Canada/United States initiatives have been undertaken to reduce phosphorus loadings to the Lakes. An effluent objective of 1 mg/l total phosphorus has been set for municipal and industrial discharges. In Ontario, wastewater treatment has been upgraded to include chemical addition for phosphorus removal. Studies indiate that the phosphorus removal sludges can be used successfully as fertilisers on agricultural land.

INTRODUCTION

This paper outlines the effects of phosphorus on water quality. It discusses programmes undertaken to reduce phosphorus discharges from municipal and industrial sources to the Lower Great Lakes and summarises the results of studies on land application of phosphorus removal sludges.

Phosphorus occurs universally in low concentrations in soil and water and is a major nutrient required by plants and animals. It is dispersed into the environment through a variety of mechanisms including municipal and industrial discharges, the spreading of commercial fertilisers, animal manures and sewage sludge and soil erosion.

EFFECTS OF PHOSPHORUS ON WATER QUALITY

It is now well established that phosphorus most commonly limits the yield in freshwater phytoplankton communities (Thomas et al., 1980). Substantial addition of phosphorus to a body of water usually results in increased algal productivity and increased decomposition of organic matter which causes depletion of oxygen. The animals also undergo profound shifts in abundance and the relative numbers of the different types. These changes are often referred to collectively as eutrophication.

Several investigators have suggested that a concentration of 20 μg/l total phosphorus in water in the spring may be used as an approximate lower limit of the condition where eutrophication is well advanced (eutrophy). They have also suggested that below 10 μg/l few, if any, of the effects of eutrophication are evident. Such waters are in a nutrient-poor condition (oligotrophy). The intermediate or transitional state (mesotrophy) is defined as being between 10 and 20 μg/l.

Using these limits as guidelines, the present trophic status of the Great Lakes is summarised in Figure 1. Only Lakes Superior and Huron are safely in the oligotrophic state. Lake Michigan is approaching the mesotrophic state, while the Lower Lakes and Saginaw Bay must all be classified as eutrophic, although Lake Ontario and the central and eastern basins of Lake Erie are not yet strongly so.

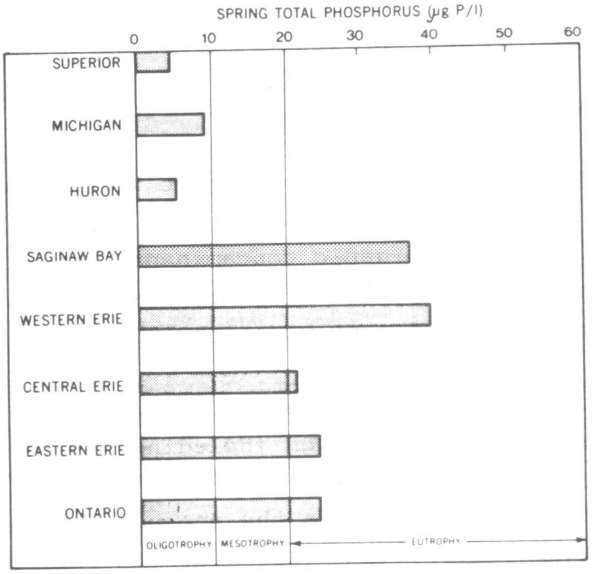

Fig. 1. Current trophic status of the Great Lakes (Thomas et al., 1980)

GREAT LAKES WATER QUALITY AGREEMENT

In 1969, the International Joint Commission reported to the Canadian and United States governments that transboundary water pollution was occurring to an extent that was causing injury to health and property on the other side of the boundary (Slater and Bangay, 1980). The report also identified a number of specific problems which required remedial action:

1. accelerated eutrophication of Lake Ontario and a condition of advanced eutrophication in the western basin of Lake Erie, largely as a result of increased nutrient inputs, especially phosphorus;

2. a disruption of beneficial uses of water as a result of changing trophic conditions;

3. dramatic changes in the species composition of commercial fish catches;

4. pollution problems related to dredge spoil disposal;

5. bacterial pollution of nearshore waters; and

6. pollution from organic contaminants, spills of oil and other hazardous substances, radioactive materials, viral contamination and thermal pollution.

A number of specific recommendations were made to deal with the problem of eutrophication including:

1. immediate reductions in the phosphorus content in detergents;

2. implementation of programmes for the reduction of phosphorus from municipal and industrial waste effluents, including a timetable for reductions;

3. the development of programmes for the control of phosphorus from agricultural operations;

4. regulation of any new uses of phosphorus which could result in appreciable additions to the lakes.

In recognition of the importance of these findings the two governments began negotiations which culminated in a new strategy for managing Great Lakes water quality. The Great

Lakes Water Quality Agreement signed April 15th, 1972 committed the governments to a scheduled reduction in phosphorus discharges from municipal and industrial sources to the Lower Lakes and called for an effluent objective of 1 mg/l total phosphorus. It also directed the IJC to undertake studies of water quality in the Upper Lakes and to provide information on the quantities and control of pollution from diffuse or nonpoint sources.

A number of important steps have been taken to reduce phosphorus input to the Great Lakes. In Canada, immediate steps were taken to reduce the phosphorus content in laundry detergents. In 1970, levels were reduced to 8.5% P by weight, and in 1972 this was further reduced to 2.2% P. In the United States, the existence of eight separate state jurisdictions has resulted in a somewhat less rapid and uniform reduction in phosphorus in detergents; however, only Ohio and Pennsylvania still do not control this source. Important reductions have also been achieved at municipal sewage treatment plants. In Lake Erie, the point source load has been reduced from approximately 10 000 metric tons/yr in 1972-73 to 5 700 metric tons/yr in 1977, and is expected to be 2 100 metric tons/yr when all controls are in place to meet the 1 mg/l phosphorus effluent limit. In Lake Ontario, direct point source discharges have been reduced from approximately 6 300 metric tons/yr in 1972-73 to 2 600 metric tons/yr in 1977, and are expected to be 1 500 metric tons/yr when all controls are in place to meet the 1 mg/l phosphorus effluent limit.

CANADA/ONTARIO AGREEMENT

To implement and accelerate pollution control programmes the governments of Canada and Ontario in August 1971 signed an agreement that secured funding for a $250 million capital works programme aimed at upgrading sewage collection systems and treatment works, including the installation of phosphorus removal equipment (Black, 1980). An additional $6 million over a 5 year term of the agreement was provided for related research studies. This was later extended for an additional 2 year period and provided an additional $1 million in research funding.

Under this funding programme, the effectiveness of uminium sulphate, ferric chloride and lime as prime coagulants r use in existing sewage treatment facilities was evaluated. predictive methodology involving jar testing techniques was veloped, whereby selection could be made of the prime coulant best suited for phosphorus removal at a particular ant. Temporary full-scale treatability studies were then rried out at selected plants to confirm the jar testing produres and determine design and operational parameters.

By December 31st, 1975 there were a total of 168 sewage eatment plants in Ontario with permanent phosphorus removal cilities in operation. By December 31st, 1977 this number d increased to 211, representing about 85% of the provincial tal sewage hydraulic capacity.

OSPHORUS REMOVAL BY PRECIPITATION

Alum, iron chloride and lime have proven effective for osphorus removal from wastewater. The main mechanism for moval is thought to be precipitate formation resulting from e reaction of aluminium, iron and calcium ions with orthoosphate ions. However, some polyphosphates and organic osphorus compounds are also removed by a combination of mplex reactions and sorption onto floc particles.

A survey of Ontario wastewater treatment plants, where cords were kept prior to and following the installation of osphorus removal systems, was conducted (Schmidtke, 1980). erage results indicated that addition of alum or iron loride for phosphorus removal increased both the mass of lids and the volume of sludge produced (Table 1). Few tario plants practise phosphorus removal using lime, and no bstantive data base exists for sludge quantity estimation.