IRCWD NEWS

WHO International Reference Centre for Wastes Disposal

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Eutrophication, Cause and Consequences

The following is an excerpt from the Swiss national report on the effects of fertilizers and agricultural wastes on eutrophication, drafted by Dr R. Gaechter of the Swiss Federal Institute for Water Resources and Water Pollution Control and Dr O. Furrer of the Agricultural Research Center, Liebefeld, Berne, Switzerland.

The cause of rapid eutrophication of all great European lakes during the past decade has undoubtedly been the unnatural increase in the supply of nutrients through domestic and industrial wastewater and through run-off and erosion of land used for intensive agriculture. This overfertilization leads to a considerable increase in plant growth along the lakeshore and in the pelagic region, with complete oxygen depletion in the hypolimnion and the formation of hydrogen sulfide (H_2S) and an ammonium ion $(NH_4)^+$ during the stagnation period.

Obviously, the relative contribution of agriculture to this phenomenon varies from one drainage area to another. We quote from "Program on Evaluation of Eutrophication Control", page 8:

"It is estimated that at the current rate of application the quantity of nitrogen usefully taken up by the crop (AGR/70.12) does not exceed 50 %, the remainder being lost by run-off and finding its way to waters (since nitrates are extremely soluble). It is estimated that in general more than half the nitrates in water, in OECD countries, come from agricultural land . . .

Since phosphorus fertilizers are readily fixed by soil components, they have a more limited effect on run-off water unless soil erosion occurs.Nevertheless careful attention should also be given to this case".

However, this does not mean that methods of reducing the run-off of nitrates must be found before the phosphorus problem can be dealt with. Eutrophication is a problem not of agricultural management but of limnology and is based on the laws of Liebig and Mitscherlich.

In the case of balanced growth, nitrogen and phosphorus are assimilated by algae in a weight ratio of about 7:1. In Switzerland, one estimates that soil used for agricultural purposes looses approximately 1,000 kg N/km² year and about 30 to 50 kg P/km² year. This corresponds to a N/P ratio in the run-off of (20 to 33) :1. That is to say that phosporus and not nitrogen is likely to be growth limiting. In contrast, domestic wastewater, because of its high content of phosphorus from washing products, has a relatively low N/P ratio of 4.2:1.

The expected N/P ratio in the water of lake tributaries has been plotted as a function of the population density in the drainage area (figure 1). The assumption was made that the nutrients in untreated sewage amount to about 3 g P/capita day and 12.6 g N/capita day and that agriculture contributes about 1,000 kg N/km² year and 30 to 50 kg P/km² year.

If untreated or mechanically-biologically treated wastewater is discharged into the tributaries, a growth limitation by nitrogen could be expected only with a population density exceeding 200 inhabitants/km². After elimination of phosphorus in a tertiary treatment step the N/P ratio never falls below 20:1. In these calculations a rather low value of (20 to 30) :1 has been used for the N/P ratio in order to account for agricultural activities. Also, phosphorus is more readily fixed in lake sediments and is lost more rapidly in the metabolism of a lake than is nitrogen. In most cases, therefore, phosphorus rather than nitrogen is the key element of eutrophication.

Vollenweider (DAS/CSI/68.27) reached the same conclusions on the basis of his observations on different lakes, and our experiments on Lake Lucerne have fully confirmed these rather theoretical conclusions.

The degree of eutrophication in a water body is determined chiefly by the absolute supply of the growth-limiting factor rather than by the N/P ratio.

In his report, Vollenweider sees tolerable and harmful loads of biologically active phosphorus as a function of the mean depth of a lake (figure 2).

Figures 2a and b, which show Swiss lakes, assume an annual phosphorus supply from the drainage area of 15 to 25 kg P/km². Such small amounts could easily be reached by the agricultural contribution alone and would consequently be sufficient to endanger even large lakes such as Lake Constance or Lake Lucerne.

It can thus be seen that reducing the phosphorus contribution from agricultural wastes and drainage is at least as important as reducing the nitrogen run-off.

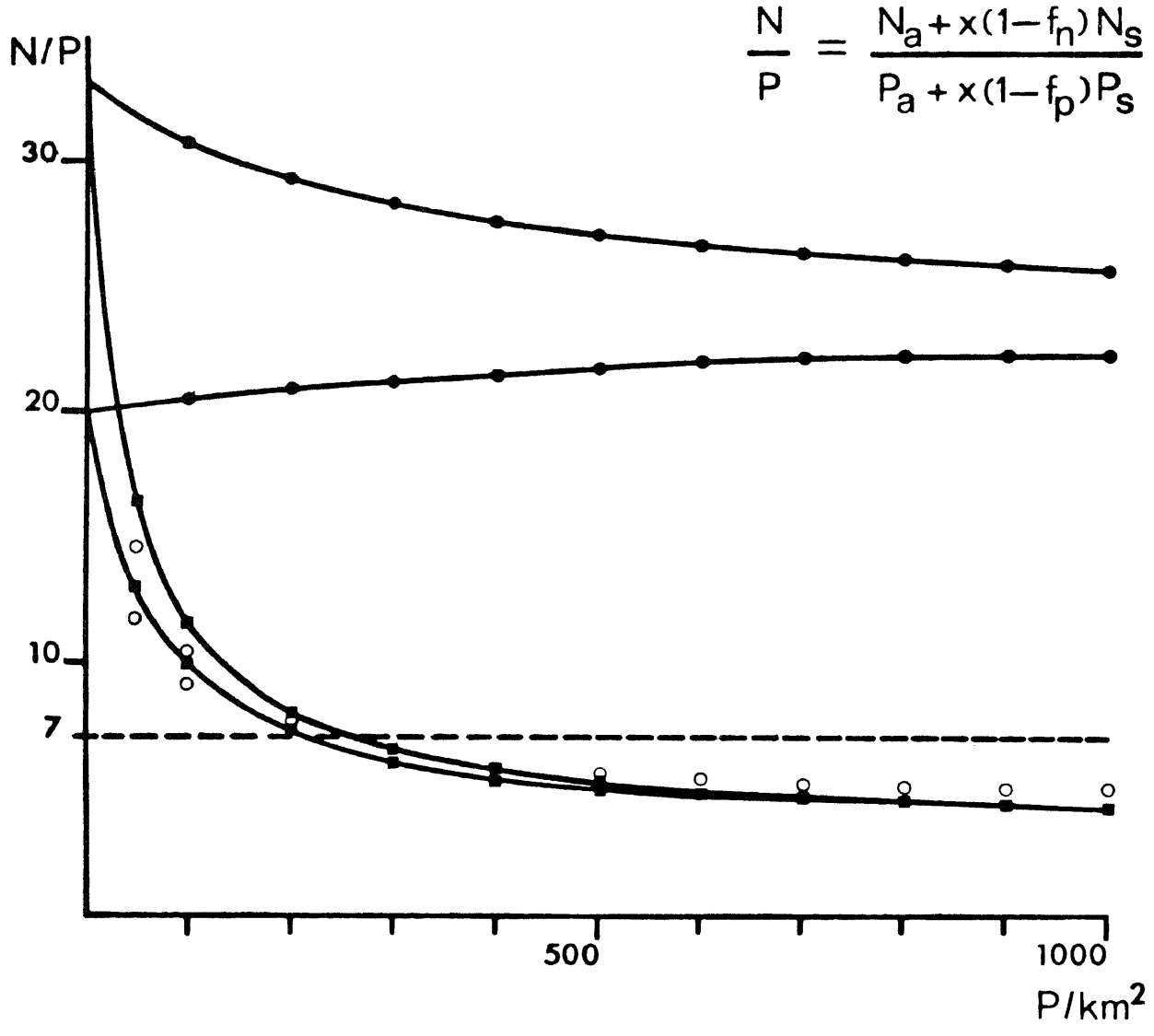

Fig. 1: N:P ratio in run-off as a function of the population density.

N_a = Nitrogen of agricultural origin (N_a = 1000 kg N/km² year)

P_a = Phosphorus of agricultural origin (P_a = 30—50 kg P/km² year)

N_s = Nitrogen from sewage (N_s = 12.6 g N/capita day)

P_s = Phosphorus from sewage (P_s = 3.0 g P/capita day)

X = Population density (inhabitants/km²)

f_n = Effect of treatment plant in nitrogen elimination (f_n = 0.5)

f_p = Effect of treatment plant in phosphorus elimination (f_p = 0.3; with "tertiary treatment" f_p = 0.9).

○—○ Without waste water treatment

■—■ With mechanical and biological treatment

●—● With mechanical, biological and tertiary treatment

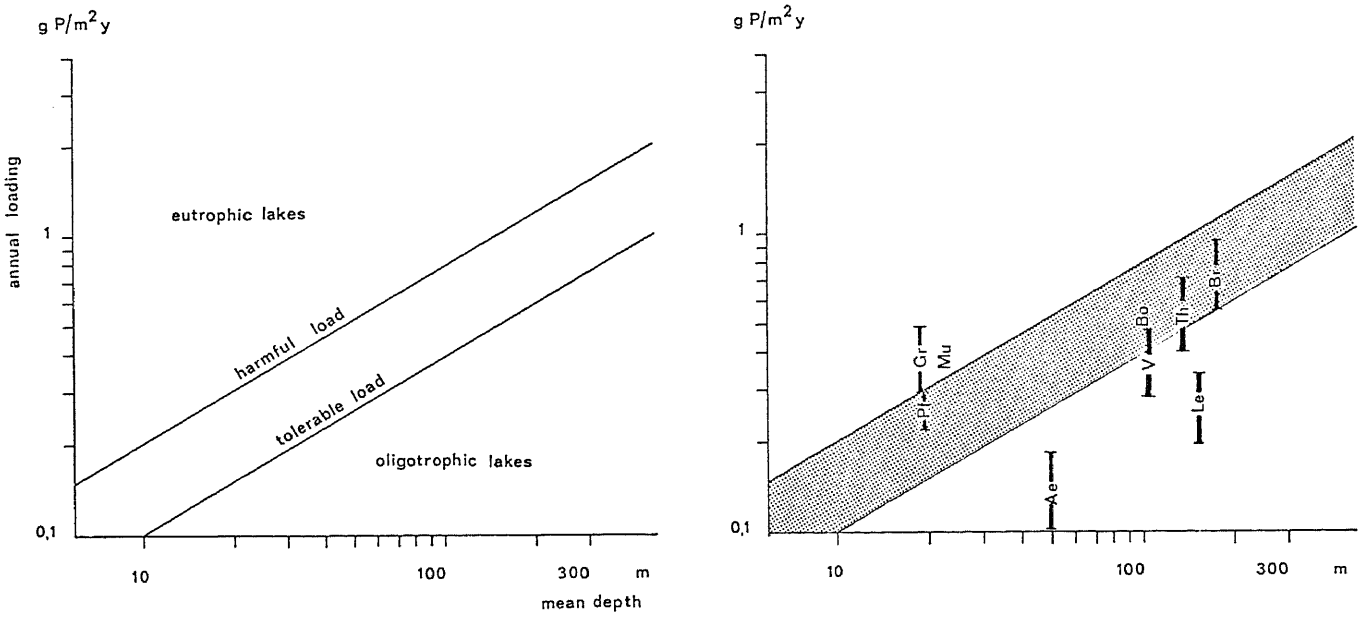

Fig. 2: Annual loading of phosphorus versus mean depth. Ae = Aegerisee, Le = Lac Léman, V = Vierwaldstättersee, Pf = Pfäffikersee, Bo = Bodensee, Th = Thunersee, Br = Brienzersee, Gr = Greifensee, Mu = Murtensee

News from WHO

Expert Committee on Solid Wastes Disposal and Control

A WHO Expert Committee on Solid Wastes Disposal and Control met at EAWAG from 15–21 June 1971. In view of the extensive scientific work on solid wastes being carried out by EAWAG and the fact that it is the host institute of the WHO International Reference Centre for Wastes Disposal, it was thought desirable to hold the meeting at the Institute, whose facilities were kindly made available for this purpose by its Director, Professor Stumm.

A number of previous Expert Committees convened by the World Health Organization have considered the problem of solid wastes in their discussions. A WHO Scientific Group met in 1966 to consider problems related to the treatment and disposal of waste water and solid wastes and to formulate research and development needs in this field. On the basis of the Scientific Group's recommendations, a research and development program was drawn up with the aim of assisting WHO Member States, particularly the developing countries, in finding and applying satisfactory solutions to these complex problems. The first step in the implementation of the program was the designation, in September 1968, of EAWAG as WHO International Reference Centre for Wastes Disposal, whose initial activities are concentrating on problems of solid wastes disposal.

The Expert Committee on Solid Wastes Disposal and Control was composed of the following eight members: Professor S.J. Arceivala, Director, Central Public Health Engineering Research Institute, Nagpur, India (Vice-Chairman); Mr. M. Assar, Under-Secretary of State for Planning and Programmes, Ministry of Health, Teheran, Iran; Dr L.-J. Coin, Chef de Service, Laboratoire d'Hygiène de la Ville de Paris, France; Dr. A.J. Dudarev, Chief Medical Officer, Leningrad, Sanitation and Epidemiological Centre, Leningrad, USSR; Mr. R. Kojetinsky, Obersenatsrat, Leiter der Gruppe Tiefbau und Verkehr in der Stadtbauamtsdirektion, Vienna, Austria; Mr. T.F. Lye, Senior Public Health Engineer, Public Health Division, Ministry of Health, Singapore (Rapporteur); Mr. D.F. Metzler, Deputy Commissioner, New York State Department of Environmental Conservation, Albany, N.Y., USA (Chairman); Professor A.M. Wright, Senior Lecturer, Faculty of Engineering, University of Science and Technology, Kumasi, Ghana. The International Solid Wastes and Public Cleasing Association (ISWA) was represented by the Chairman of its Scientific Commitee, Professor O. Jaag, former Director of EAWAG and the International Reference Centre. The Committee was assisted by a WHO Consultant, Mr. F.L.D. Flintoff, Consultant Public Health Engineer – Solid Wastes, Thorpe Bay, Essex, England; and by three WHO Temporary Advisers; Mr. J.-V. Arpin, Director, Department of Roads, City of Montreal, Canada; Mr. H.H. Connolly, Deputy Commissioner, Office of Solid Waste Management Programs, Environmental Protection Agency, Rockville, Md., USA; and Mr. H.R. Wasmer, Manager, WHO International Reference Centre for Wastes Disposal, EAWAG, Dübendorf, Switzerland. Mr. Prescott Stevens, Acting Chief, Wastes Disposal, Division of Environmental Health, World Health Organization, was Secretary to the meeting.

The Expert Committee discussed the impact of solid wastes on health and welfare, including socio-

economic aspects; reviewed present knowledge and technology in the collection, treatment and disposal of solid wastes; outlined recommendations for research and development; discussed planning and operation of solid wastes systems, including training of personnel; and set down a number of guidelines for policy and action at different levels.

Full details about the report of the Committee will be given when it becomes available.

Reorganization of Division of Environmental Health, WHO

With effect from 1 October 1971, the units of Community Water Supply (CWS), Sanitation Services and Housing (SSH) and Wastes Disposal (WD) were disestablished. Two new units were created: Community Water Supply and Sanitation (CWSS) with Mr L.A. Orihuela as Chief, and Development of Institutions and Services (DIS) with Mr J.N. Lanoix as Chief.

The functions of the Community Water Supply and Sanitation unit will include advising on community water supply and wastes disposal, on community sanitation including the hygiene of housing and food sanitation, and on engineering measures for protection from disease vectors.

The functions of the Development of Institutions and Services unit will include advising on the development of the services and institutions required for the effective planning and management of environmental health programs and of the manpower required for such programs.

New publications

We have also received information from WHO that the publication "Waste Stabilization Ponds", by E.F. Gloyna (World Health Organization: Monograph Series, No. 60), has now been published. Waste stabilization ponds provide useful methods of waste-water treatment and disposal for growing communities where both funds and personnel are in short supply. Such ponds are especially suited to countries with tropical and sub-tropical climates. This monograph summarizes the available information on waste stabilization ponds. It describes the past and present use of such ponds throughout the world, defines acceptable design criteria based on public health considerations, suggests alternative approaches to design, and deals with the operational problems that ultimately determine the success or failure of any waste-water treatment facility. In addition, useful infomation is provided on the theory of biological waste treatment and on the control of disease transmission in ponds. Copies of this publication, which is just off the press, will reach the collaborating institutions in the near future.

Meetings and Consultations

IRC WD has been invited to participate and collaborate in a Consultation to be held by WHO on "Methods of Waste-water Treatment and Health Safeguards in Relation to the Re-use of Effluents" from 30 November to 6 December 1971 in Geneva. The group will consider the latest technological developments in the renovation of waste water to allow its safe use for agricultural, industrial, recreational and domestic purposes, and will attempt to put in perspective the present knowledge on the various aspects of the matter. Topics to be considered will include: (i) intentional and unintentional re-use of waste water for various purposes and in different parts of the world; (ii) specific health hazards associated with waste-water re-use; (iii) status of waste-water treatment for re-use; (iv) laboratory control and surveillance of the quality of water intended for direct re-use; (v) future trends and needs in health safeguards for waste-water re-use.

Periscope

Brazil

The Brazilian Association of Solid Wastes and Public Cleansing (Associaçao Brasileira de Residuos Solidos e Limpeza Publica ABLP) was established in Sao Paulo, Brazil to study and solve problems relating to solid wastes and public cleansing. The Director of this new association is Professor W. Engracia de Oliveira.

India

The two following reports concern the activities and programs of the Central Public Health Engineering Research Institute (CPHERI) in Nagpur, India. Its publication, the "Technical Digest" gives further details and information on research projects carried out by this institute.

Refuse Disposal Studies at Calcutta, Technical Digest, 1971, No 15

The CPHERI in Nagpur has just completed the first comprehensive investigation of refuse disposal in India by studying its composition, physicochemical properties, present disposal practices and economic aspects of improvements over existing methods.

At present, refuse in Calcutta is disposed of by uncontrolled dumping. An economic analysis revealed that mechanical composting, even after sale of the product, will cost three times as much as dumping, sanitary landfilling more than three times, and incineration without heat recovery twelve times the dumping costs.

Studies must be carried out to reduce the cost of mechanical composting. Manual composting in pits

is the most widespread method in India, where land is inexpensive. The introduction of more mechanization would, however, be an advantage to reduce health hazards and make the approach more scientific.

Since the refuse is mainly composed of garbage, broken earthenware and ashes, and since inorganic matter prevails, the density is high and the calorific value low. Incineration costs are therefore very high.

Bituminous Coal: A substitute filter media for anthracite, Technical Digest, 1971, No 18

The advantages of anthracite media in two-layer water filters over conventional rapid sand filters have been well-established. With a view to introducing this method in India to improve the performance of overloaded conventional plants, the CPHERI set out to locate indigenous sources of anthracite. Since no anthracite was found, the local deposits of bituminous coal were taken into consideration. Bituminous coal was compared with anthracite coal in extensive tests. The results indicated that indigenous, good-quality bituminous coal, despite its lower density and hardness, was a suitable substitute for anthracite coal. Laboratory studies in 15 cm dia column filters have shown that with a two-layer filter consisting of about 30.5 cm of 0.9 mm – 1.4 mm coal followed by about 38.1 cm of 0.45 mm – 0.9 mm sand, twice the rate of conventional filtration could be achieved with no deterioration in filtrate quality.

Congresses and Symposia

The Centre belge d'Etude et de Documentation des Eaux (CEBEDEAU) will hold its 25th international congress in Liege from May 16 to 19, 1972. Its aim is to study water, air and corrosion problems. Some of the specific items on the provisional agenda are: the position of the Research Center towards environmental protection, planning of the utilization of rivers, concerted action in water management, biodegradability and reuse of plastics, protection of selected reserves against atmospheric pollution, corrosion and anti-corrosion in warm and cold water feeding in buildings and factories, and boiler water problems.

IRC Flashback

The time span from July 1970 to June 1971 was the second full year of operation for the IRC and can be viewed as a period of consolidation after two years of growth. As in previous years the IRCWD was visited by more than 40 guests traveling on WHO or other fellowships. The IRC organized about 120 individual visiting days in order to meet the particular interests of each fellow.

Professor Jaag was appointed guest professor at the "Ecole Mohammadia d'Ingénieurs" in Morocco. This university offers a graduate study program in sanitary engineering sponsored by WHO. A two weeks technical study tour in Switzerland was organized by the IRC for the first graduates of this school.

A highlight of this year's activities was the WHO Expert Committee on Solid Wastes Disposal and Control which was held at the host institute of the IRC in June 1971.

Work on the Solid Wastes Management Information Storage and Retrieval System has been continued and the accumulated backlog of information is now being introduced into the system. Documentation activities, which include reviewing literature, abstracting, translating and indexing, have brought us to the present level of 500 abstracts. Articles for abstracting were selected from 30 European and American periodicals and publications.

Our documentation system is based on co-ordinate indexing; the KEYDEX machine, system McBee, enables the user to punch the keycards and, at the same time, view them. Between 5 to 15 descriptors are assigned to each abstract. The respective squares, indicating the number of the abstract, are punched on 480 keycards. These keycards correspond to the descriptors in the thesaurus.

The fundamental task, which has now been accomplished, was developing the thesaurus. The first few hundred abstracts were used to put the draft thesaurus to the test. Except for a few descriptors, which were added or deleted, the indexing terms proved to be appropriate. Thus the thesaurus could be established definitely; it encompasses 4 sections: I) Alphabetical list of descriptors with cross-references; II) Listing of descriptors under various main headings; III) Simple alphabetical list of descriptors; IV) Glossary of terms (about to be completed).

With the finalized thesaurus on hand, we were able to start punch card processing. By 1972 we shall have enough data filed to begin information services.

A study of legislation and regulations governing solid wastes disposal in countries around the world was carried out. Legal provisions for wastes disposal differ from country to country; some countries have no legislation at all while others have carefully thought-out systems. Most often, however, individual regulations on wases disposal are found in acts that are totally unrelated to environmental pollution control. A compilation of regulations in all countries would therefore be commendable. As it was extremely difficult to obtain documents, only 23 countries – half of them European – could be covered. A summary of wastes disposal legislation was made for each country and a bibliography and register of keywords added. The aim of the project was to give a comprehensive view of the heterogenous

system of regulations and to point out the need for a monolithic code for solid wastes disposal for the sake of more effective pollution control.

A "Survey of Solid Wastes Management Practices" was published and sent to our Collaborating Institutions. This paper represents an attempt to outline the essential measures to be taken in the methodical disposal of wastes. It is intended as an aid to public health officials, municipalities or public interest groups. The advantages and disadvantages of landfilling, composting and incineration are summarized at the end of the respective chapter. Generally, the principle of re-cycling and especially composting is stressed; the sore points – the problems of accounting, marketing and quality – are explained at some length. On the other hand, re-cycling of industrial wastes has not been dealt with, as research on these manifold problems is still at a preliminary stage.

Another IRC project was to study the possibilities of glass and plastic segregation from household refuse. It is well known that segregation of household refuse at source is not practicable due to public indifference to waste disposal. In the meantime, however, people have become environment-conscious and a survey of the extent of this new awareness seemed worthwhile. Buchs, a small Swiss town was chosen for a public opinion poll (random-sample) to find out whether households, restaurants and grocers were willing to segregate glass and plastic bottles from the rest of the household waste. The reuse of the collected cullet was guaranteed by glass manufacturing firms and a special project was set up to investigate the reuse of a variety of different plastic materials. The result of the poll prompted the town to start separating bottles of glass and plastic from waste. This experiment is now under way and will take one full year.
The decline in ecological stability is a universal problem and involves human health. Different branches of science deal separately with it. For instance soil science focuses on erosion; water pollution control on eutrophication. As humification is known to prevent erosion and to retain suspended dissolved nutrients biologically, a program for the benefit of both agriculture and water protection would be useful. Humified solid organic wastes could play a part in solving the problem. Together with the Federal Institute for Water Resources and Water Pollution Control – to whom we are associated – and in collaboration with the Federal Research Stations of Agriculture we set up a project to coordinate soil and water research. The investigations are based on the following theses:

- Only parts of the highly-concentrated soluble nutrients are taken up by plants; the rest seeps into the water. Liquid manure may have similar effects.

- The immediate supply of nutrients to the plants, which short-circuits soil biology, reduces the variety of species in a biotop, at the same time leading to the proliferation of one paricular species, which possibly may be detrimental.

- The excessive consumption of nutrients leads to an enlargement of the cells which weakens the cell membranes. Reduced stability, higher susceptibility to pests combined with increased pesticide application are the consequences. Parts of the excess poisons reach the waters.

The project will initiate a fundamental and applied research program on the interdepence of soil and water with special attention paid to humification problems. Thus disposal of organic wastes and the economic side of composting may be seen from a new angle.

Abstract of a Paper on Microbiological Air Pollution through Sewage Treatment Plants

by Prof. K. Wuhrmann of the Federal Institute for Water Research and Water Pollution Control

Our investigations confirmed that aerosols containing microorganisms from wastewater are formed during wastewater aeration in aerated sand traps, aeration tanks or activated sludge plants and aerobic sludge stabilization tanks. The size and amount of aerosol particles, and through them the dispersion of microorganisms, are contingent on the type of aeration system applied.

The spray irrigation installation used to prevent foam formation in activated sludge plants proved to be the greatest source of aerosols.

In the case of aeration by means of pressurized air, medium-bubble aeration at low immersion depth, if compared with the fine-bubble system, produces a much greater density of aerosols. Both types of aerosol particles, however, show similar sedimentation properties. It is assumed that the aerosols are formed mainly when the air bubbles burst at the water's surface.

In the case of mechanical aerators, brushes and turbines were equally effective in producing aerosols. Under both systems the aerosol density was greater directly over the aeration tank than for medium-bubble, pressurized-air aeration. Turbines, however, produce an aerosol with considerably more rapidly sedimenting particles than brush or medium-bubble aerators. As a result the aerosol density two meters

next to the aeration tank is considerably lower for turbine aeration than for the two other systems; in fact, the aerosol density next to the tank corresponds to that of fine bubble pressurized-air aeration.

The absolute germ count in the air 2 meters next to the aeration tanks in the case of fine-bubble or turbine aeration is equal to that of busy streets and intersections or crowded rooms. From measurings carried out to determine germ reduction at increasing distances from the source following the direction of the wind it could be concluded that the aerosol particles from tanks operated on the basis of fine-bubble or turbine aeration did not contain more germs than are normally found in nature or uncrowded rooms.

In view of the decrease in the germ count with increasing distance from the source (with the wind coming from the direction of the source), a comparison of the air 50 m from the source and that above fields and forests revealed that with a 2 m/sec. wind velocity the aerosols from fine bubble aeration tanks or turbine aerators did not cause any abnormal rise in the germ count in the air 50 m from the source. In the case of a source with strong aerosol dispersion such as a medium-bubble aerator, however, the germ count in the air becomes normal only at a distance of 200 m.

The aerosols from the aeration tank (measured at source) revealed the same relative **E.coli** germ content as the wastewater. Thus the relative density of pathogen organisms in the aerosols at source corresponds to that found in wastewater. Since a number – albeit very small – of pathogens of various types are always found in municipal wastewater the possibility of finding aerosols with a few germs that might cause respiratory infections cannot be excluded. But since such germs in aerosols are very rare they can hardly be considered a health hazard for humans. This coincides with epidemiological experience; as far as we know no treatment plant has ever reported a case of respiratory infection. Tests with anaerobic spores **(Clostridium perfringens** and **tetani)** led to negative results.

Answers to Pollution Puzzle

1 B	2 E	3 A	4 R		5 A	6 R	7 O	8 N		9 B	10 I	11 L	12 L
13 E	M	N	E		14 G	O	B	I		15 E	G	A	U
16 R	E	A	D		17 A	L	O	G		18 R	O	S	S
19 M	U	L	T	20 I	P	L	E	H	21 E	A	R	T	H
			22 A	C	E			23 T	A	T			
24 H	25 I	26 P	P	Y		27 F	28 L		29 R	E	30 U	31 S	32 E
33 O	G	R	E		34 P	I	E	35 R		36 S	N	O	W
37 I	L	E		38 P	E	L	T	O	39 N		40 I	D	E
41 S	O	S		42 M	A	T	T	E	R		43 T	A	R
44 T	O	S	45 S		46 S	E	E	S		47 L	E	S	S
			48 L	49 A		50 R	R		51 N	A			
52 R	53 E	54 F	U	S	55 E			56 C	O	G	57 N	58 A	59 C
60 A	G	E	D		61 E	62 T	63 N	A		64 O	O	Z	E
65 A	G	O	G		66 L	I	A	R		67 O	D	O	R
68 S	I	D	E		69 S	E	P	T		70 N	E	S	T

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