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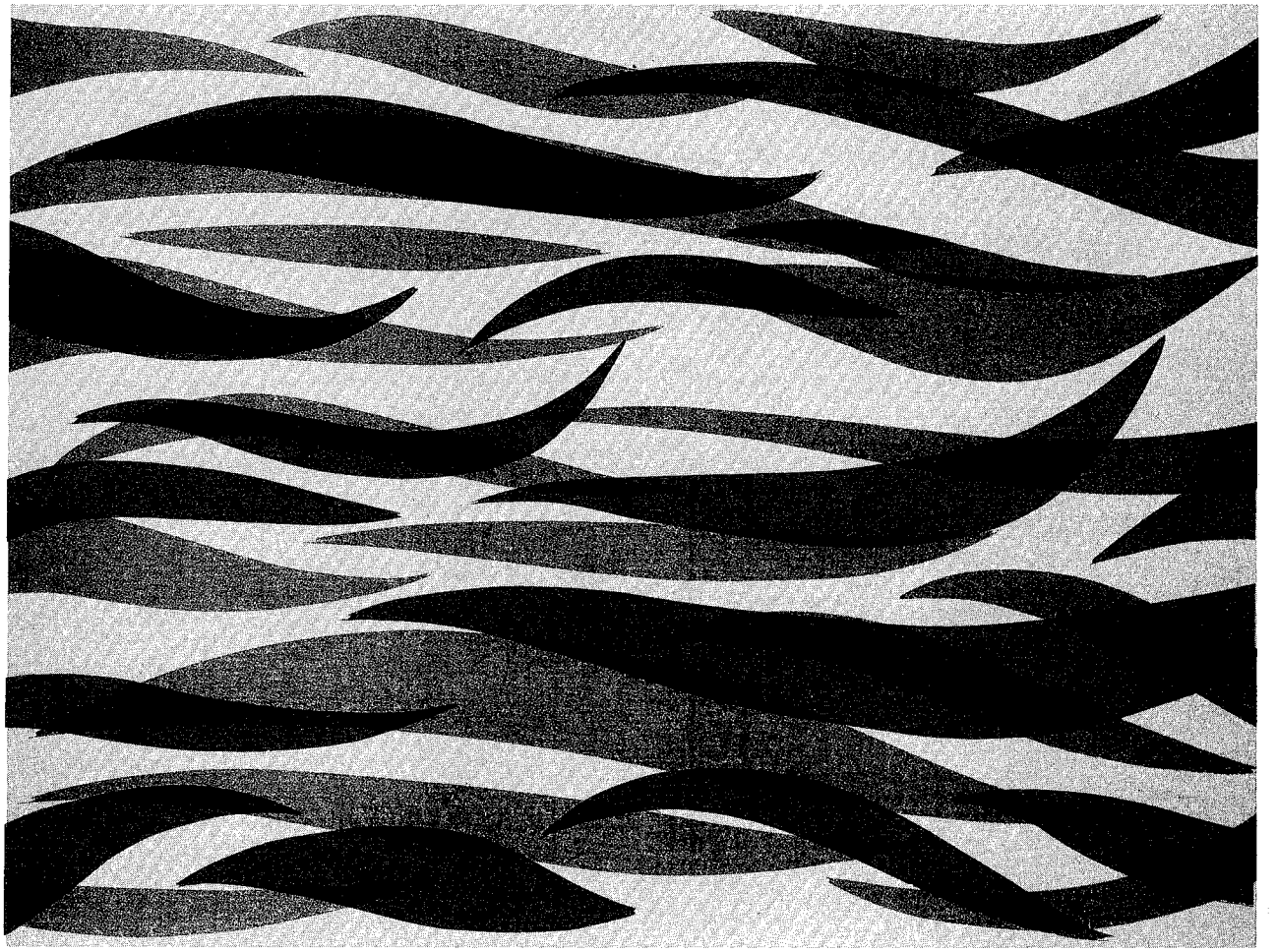
Water Resources Research 1970 : Proceedings of the Water Research Conference

William C. Kennard, ed.
Institute of Water Resources

PROCEEDINGS OF THE CONFERENCE WATER RESOURCES RESEARCH - 1970

Report No. 13 September 1970



INSTITUTE OF WATER RESOURCES
The University of Connecticut

Report No. 13

WATER RESOURCES RESEARCH 1970

Proceedings of the

Water Research Conference

Held in the Auditorium

College of Agriculture and Natural Resources Building

The University of Connecticut

Storrs, Connecticut

May 18, 1970

Edited by

William C. Kennard

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FOREWORD

These Proceedings include abstracts of papers presented at the Conference held by the Institute of Water Resources at the University of Connecticut on May 18, 1970.

Two similar conferences have been held previously by the Institute, one on April 28, 1965 and the other on May 18, 1966. It is our intent to convene such meetings every three to five years as a means of informing all interested individuals about water related research activities at the University.

The title of each presentation is the same as that of the research project. Also given for each are the personnel, academic departments, planned duration and the objectives of the investigations. Each abstract is a brief summary of accomplishments to date and plans for the future.

I would like to express my appreciation to Dr. R. W. Wengel, Associate Professor of Agronomy, University of Connecticut for his special efforts in arranging for the Conference. Thanks also are extended to Mr. C. E. Thomas, Jr., U. S. Geological Survey, Hartford, who served as moderator of the morning session and to Dr. G. Árnason, Center for the Environment and Man, Inc., Hartford, who handled the afternoon session.

William C. Kennard
Director
Institute of Water Resources

INTRODUCTION

Research Goals and Programs
of the Institute of Water Resources

A digest of remarks by
W. C. Kennard, Director, Institute of Water Resources

Since its activation in 1964, the Institute of Water Resources has sponsored an increasingly diverse and complex program of water resources research. These have related to the scope of the Institute which is as follows: "Research on water in any part of the hydrologic cycle which can be used directly or indirectly by man comes under the purview of the Institute. It includes any study which adds to the knowledge of the quantity, quality, nature or uses of water, including those designed to provide information on the nature, sources, production, behavior, transport, and conservation of water, including socio-economic aspects, for agricultural, domestic, industrial, municipal, and recreational uses by citizens of the State."

RESEARCH PROGRAM

To date, the objectives of 11 projects have been achieved and the efforts terminated. These have included studies on topics such as ground water movement, erosion, micro-climate, water law and water economics, saline water conversion, heat pollution and others. Reports based on these investigations have been published in a range of scientific journals, and several have been released as Institute reports. In addition, a number of students have received either Masters or Ph.D. degrees as a result of their work on the experiments. The present research program of the Institute is much broader than is indicated by the projects scheduled for discussion today. Due to time limitations, it was possible only to schedule 11 of our projects. Additional ones are:

"Ion-Ion and Ion-Molecule Interactions in Aqueous Salt Solutions" under Dr. W. L. Masterton of the Chemistry Department

"The Velocity Dependence of the Total Cross Section for Alkali-Water Scattering" directed by Drs. T. I. Moran and E. Pollack of the Physics Department

"Changes in Resistance to Flow of Water Through a Soil-Plant System" under Dr. B. E. Janes of the Plant Science Department

"The Quantity and Movement of Nitrates in Soil Water in Two Connecticut Soils Treated with High and Low Levels of Inorganic Nitrogen Fertilizer" under Drs. G. F. Griffin and R. W. Wengel of the Agronomy Section, Plant Science Department.

"Chemical Analysis and Process Classification of Constituents of Effluents" of which Dr. T. Helfgott of the Civil Engineering Department is the principal investigator

These will be reported on at a future Institute conference.

A number of additional projects are handled administratively by the Institute. Some of these are exploratory in nature and have no formal funding; others are supported by agencies such as the Connecticut Research Commission, the Federal Water Pollution Control Administration, the Department of Housing and Urban Development, the Storrs Agricultural Experiment Station, and others.

Ten graduate assistantships also are awarded annually by the Institute using University funds. These have been in disciplines such as agricultural economics, biology, chemistry, economics, engineering, fresh water fisheries, geology, physics, political science, and sociology.

Altogether, the Institute has supported research in 22 different academic units of the University. We, thus, are achieving the broad goals and purposes for which the Institute was established.

PLANS FOR THE FUTURE

The research program is a dynamic one with projects terminating as their objectives are accomplished and new experiments being initiated. Several new efforts already have been selected and approved for activation July 1, 1970. Included are:

"Effects of Simultaneous Variations of Diel Changes of Temperature, Dissolved Oxygen, Salinity and a Pollutant on the Growth of White Perch" by Dr. W. R. Whitworth of the Plant Science Departments's Freshwater Fisheries Section

"Interrelation of the Morphology and Physiology of a Plant and the Resistance to Flow of Water Within a Plant" to be carried out by Dr. B. E. Janes, Plant Physiologist in the Plant Science Department

"A Chemical Analysis of the Earthy-Musty Odor in Water" under Dr. R. P. Collins in the Biological Sciences Group

"Stability Criteria for Bound-Rock Erosion-Proofing" directed by Professor C. J. Posey of the Civil Engineering Department

"Hydrological Analyses Using Atmospheric Vapor Data" under Dr. P. Bock of the Civil Engineering Department

Further studies on "Water Quality Control with Synthetic Polymeric Flocculants: Effects of Metal Ions on Flocculation of Biocolloids" to be directed by Dr. J. K. Dixon of the Chemistry Department of the Torrington Branch and Dr. R. C. Tilton of the School of Medicine at Farmington

We will, of course, also continue exploratory research, continue to support outstanding graduate students in many disciplines relating to water resources use and development, and assist staff scientists in developing effective research efforts.

SUMMARY

The program of the Institute has become increasingly diverse in the approximately six years that it has been in existence. Projects in the agricultural, biological, engineering, earth, social and physical sciences have been or now are active. Continued expansion, both in scope of the research and in the number of projects, is planned.

The results of these investigations will, in many cases, have direct application to solving problems of water resources use and development in Connecticut and will result in important contributions to the fund of scientific information about water in a broad range of disciplines.

PROJECT TITLE: Air Oxidation of Organic Compounds in Aqueous Systems

PERSONNEL: D. W. Sundstrom

DEPARTMENT: Chemical Engineering

PLANNED DURATION: July 1968 through June 1971

OBJECTIVE: To determine the factors that limit the destruction of organic compounds in a wet oxidation process

REPORT OF ACTIVITIES AND PLANS:

Organic chemicals can be oxidized chemically in an aqueous system by heating under pressure in the presence of air. When applied to the disposal of aqueous municipal and industrial wastes, the technique is referred to as wet oxidation. Since the process is a chemical rather than a bacterial oxidation, the system is less sensitive to environmental changes.

The main application of wet oxidation is in the disposal of municipal wastes. In these systems the reaction is conducted at temperatures from 450 to 550°F and pressures from 1000 to 2500 psia. The rate of oxidation increases as the temperature of the system is increased. Pressure is needed to maintain the liquid phase and to regulate the amount of water vapor leaving in the effluent gases. Reduction of chemical oxygen can exceed 90%.

Wet oxidation can also be applied to the disposal of many industrial wastes. In particular, the technique should be effective on petrochemical and pulp and paper discharge streams. Since the wet oxidation process handles dilute aqueous systems, prior concentration of the waste stream would not be necessary in most cases.

The purpose of this research is to provide a better understanding of some of the factors that control the destruction of organic compounds by wet oxidation. During the project, the rate and extent of oxidation of several organic compounds will be examined over a range of temperatures, pressures, and concentrations. Since the overall rate of reaction is governed by both mass transfer and chemical kinetic factors, the relative magnitude of these rate processes will be established.

The laboratory equipment is designed to handle temperatures to 650°F and pressures to 3000 psia. The reactor is a one liter autoclave equipped with a variable speed agitator. The autoclave can be operated as a batch, semi-batch, or flow reactor.

For heterogeneous reactions, the reactant is made in the form of a cylindrical disc and attached to the drive shaft of the agitator. Only the lower surface of the disc is exposed to the oxygen-saturated water. A rotating disc geometry permits separation of the chemical kinetic and mass transfer effects. Since the diffusional resistance on a rotating disc can be theoretically calculated, the surface chemical kinetics can be extracted from the overall rate data.

For homogeneous reactions, a solution of organic material in water is heated to the desired temperature and pumped into the reactor. Air is bubbled through the autoclave to provide oxygen for the reaction. Mass transfer is influenced by the degree of agitation.

Waste treatment plants handle a vast array of soluble and insoluble chemical compounds. With a complex mixture of compounds, analytical problems would obscure interpretation of results. The initial studies are being limited to molecules that give fairly simple product distributions. We have found, for example, that carbon is very unreactive over a wide range of conditions. As a better understanding of the process is obtained, the experiments will be extended to more complex materials.

PROJECT TITLE: Development of Instrumental Techniques for the Analysis of Trace Organic Constituents in Water

PERSONNEL: R. P. Collins and F. A. Halim

DEPARTMENT: Regulatory Biology Section, Biological Sciences Group

PLANNED DURATION: September 1968 through June 1970

OBJECTIVE: To develop techniques for the analysis of taste and odor constituents in water

REPORT OF ACTIVITIES AND PLANS:

Objectionable tastes and odors produced in public water supplies by microorganisms have not received a great deal of attention. The primary reason for this is a lack of instrumental techniques for the handling of extremely small amounts of material. The purpose of the present investigation was to develop techniques for the large-scale culture of taste and odor microorganisms, as well as developing techniques for the analysis of the flavor constituents.

The organism used in this study was Streptomyces odorifer which imparts a musty or earthy odor to water. The organism was grown in fermentation vessels containing 12 liters of a potato dextrose medium. After inoculation, the fermentation vessels were placed in a New Brunswick fermentor and incubated at 25°C for 48 hours.

At the end of the growth period, the cells and culture medium were steam distilled. The steam distillate was freeze-concentrated, and the concentrated material was extracted with petroleum ether for 72 hours in a liquid-liquid extractor. The petroleum ether was dried, concentrated to a small volume, and analyzed by gas-liquid chromatography.

The gas chromatograph used was equipped with a dual flame ionization detector. The column used 80-100 mesh acid washed, silanized chromosorb W as the solid support, and this was coated with 10% SE-30. The instrument was also equipped with an effluent splitter to permit collection of compounds as they exited from the gas chromatograph. In order to collect material for infrared and mass spectrometry, the compounds of interest were trapped by means of glass U-tubes as they exited from the gas chromatograph.

Infrared spectra were obtained on a Perkin-Elmer 137 infracord (KBr disks), and mass spectra were obtained on an AEI M.S. 12 mass spectrometer using the gas inlet system ion source operated at 250°C.

In order to determine which compounds gave rise to the odor, each compound was smelled as it exited from the gas chromatograph. Three compounds were responsible for the earthy aroma produced by S. odorifer. An analysis of compound 1 showed it to be 2-exo-hydroxy-2-methylbornane. The second compound was shown to be trans-1, 9 dimethyl-trans-10-decalol or geosmin. The third peak was unidentified, but it has an empirical formula of $C_{15}H_{22}O$.

The final phase of this work will be concerned with the identification of the unidentified peaks having the empirical formula noted above.

PROJECT TITLE: Individual Waste Disposal Systems

PERSONNEL: W. C. Wheeler, N. N. Pillai, J. J. Kolega and B. J. Cosenza

DEPARTMENT: Agricultural Engineering and Microbiology Section, Biological Sciences Group

PLANNED DURATION: May 1965 through June 1970

OBJECTIVE: To determine the effect of oxygen and temperature on the overall operation of individual septic tank type disposal systems

REPORT OF ACTIVITIES AND PLANS:

The waste disposal problem in areas not served by sanitary sewers is becoming progressively more acute. This is particularly true of suburbia where the density of population is high and land suitable for septic tank use is very limited. Package aeration plants are now on the market and may be a solution to many of these problems.

Extended aeration plants commonly used admit the raw sewage to a tank where it is mixed and aerated by one of several methods. The overflow from this tank goes to a clarifier where solids settle and are returned for further aeration. The effluent from the clarifier usually contains some solids that are in the advanced stages of oxidation and these are removed by settling. The effluent is then disinfected before it is allowed to reach any water course. Certain operational difficulties are inherent in such systems. Solids escape in the effluent when shock hydraulic loading occurs, and this reduces the efficiency of the operation. Foam and floating sludge, due to denitrification, require special attention, and aeration devices are subject to frequent failure.

Tests were made on devices and methods for injecting oxygen (air) into liquids. A sudden-expansion type aspirator was developed which transferred more than 3.5 pounds of oxygen per HP hour at standard conditions. This proved to be considerably more efficient than venturi type aspirators or common types of diffusers.

A system was designed to use a sudden-expansion type aspirator and also to incorporate features that would overcome some of the faults of presently used extended aeration plants. A two-compartment tank was used for aeration. The bottoms were connected by pipes to the suction side of a centrifugal pump. The pumped liquid was dischared through pipes leading to sudden-expansion type aspirators located above each compartment. The jets from the aspirators were directed into each compartment thereby reducing the formation of foam. Recirculation provided the necessary mixing. Shock loads were received in the first compartment. The head was increased and subsequently the liquid entering the pump from the first compartment was greater, and this continued to be so until the levels in the two compartments were equal. The differential pumping effect gradually moved the liquid to the second compartment where it overflowed to a clarifier. Sludge collected at the bottom of the clarifier was returned to the pump and recirculated. For the last series of tests, a fourth tank was added and it performed satisfactorily as a denitrification chamber.

Sewage from the primary settling tank at the University's Treatment Plant was used for the experiment described above. This effluent has a BOD of approximately 230 ppm and suspended solids of approximately 240 ppm. With a detention time equivalent to 13 hours, the effluent was clear and practically odorless. Its BOD was 23 ppm and the suspended solids were 26 ppm. When the unit was operated with a detention period of 24 hours, the discharged effluent contained BOD and suspended solids of less than 5 ppm. Similar results were obtained in tests that used septic tank effluent.

This interdisciplinary project will be closed on June 30, 1970. Reports are being prepared on earlier research with septic systems and also on the aerobic system described above.

PROJECT TITLE: Experimental Studies of Air and Water Interfacial Interaction

PERSONNEL: J. D. Lin

DEPARTMENT: Civil Engineering

PLANNED DURATION: May 1968 through June 1971

OBJECTIVES: To investigate the mechanics of interaction between turbulent wind and wind-generated surface waves in a wind-wave channel and to understand the processes of dispersion, diffusion and mixing of pollutants under the action of turbulent wind-waves

REPORT OF ACTIVITIES AND PLANS:

Effluents from outfalls to a large body of water rise toward the surface after an initial phase of turbulent jet diffusion. These pollutants, confined within a thin surface layer, further undergo a process of dispersion and diffusion by drift current and waves generated by prevailing wind. Few existing experiments are aimed at studying this process. The research of a closely related problem of wave generation by wind has led us to a general understanding of the process of wave generation and the mechanism of energy transfer; however, it is as yet limited to the qualitative stage of success. The process of wave generation is generally divided into the duration limited case (the growth of waves under increasing intensity of wind in an infinite fetch) and the fetch limited case (the growth along an increasing fetch under statistically stationary wind.) Both eventually approach the "equilibrium" waves. Dispersion and diffusion are necessarily slower processes; therefore, the "equilibrium" waves are of primary interest. The energy transfer is measured in terms of power density spectrum of waves, while the wind intensity enters as a parameter through a friction velocity. For the present study, wind turbulence must be considered in addition to the variables in the theory of wind-waves. The drift current is caused by the particle motion of waves and by the drag of wind over the wave crest. How, then, can one determine the energy in the drift current and partition it among the sources? The processes of diffusion and mixing are best, in this case, investigated by the consideration of energy dissipation. Can one assume that the horizontal dispersion and diffusion predominate over the vertical mixing? How can one divide the energy in the "equilibrium" waves into components so that individual process can be isolated for a meaningful analysis?

The purpose of the present project is to make a coherent study of the wind-wave interaction in relation to the processes of dispersion and diffusion by drift current and turbulent eddies in the surface layer. The experimental program is divided into three phases (1) the construction of a 36-foot wind-wave channel with a 24" x 20" cross section capable of producing two-dimensional wind at a near-zero pressure gradient; (2) the measurement of mean profiles and turbulent characteristics of wind, and power density spectra of waves; and (3) the investigation of drift current and the properties of diffusion.

The first phase of the project is completed. The measurement of a boundary layer over a solid surface has been conducted for a number of streamwise and transverse stations with and without pressure gradients as a survey of the channel characteristics. The data indicate a sufficient region of two-dimensional core flow under a near-zero pressure gradient. The same program will soon be carried out over water and with the additional measurements of wind turbulence and of surface waves as indicated in the second phase. Various procedures will be tried to determine drift current and diffusion properties.

PROJECT TITLE: Reverse Filter Erosion Protection

PERSONNEL: C. J. Posey, H. Singh, N. Ahmed, N. Pillai, A. Dutt and T. S. Basur

DEPARTMENT: Civil Engineering

PLANNED DURATION: September 1965 through June 1969

OBJECTIVES: To investigate the efficacy of the reverse filter in preventing the erosion of fine-grained materials and to develop design criteria for its economical application

REPORT OF ACTIVITIES AND PLANS:

As urbanization progresses, more and more natural watercourses are being replaced by artificial channels. Where they are not erosion-proof, soil is washed away to muddy the water and repairs are required. The more expensive linings, concrete and asphalt, too often collapse, calling for complete removal and replacement.

The pressure variations caused by turbulence or induced by secondary flow can lift and rupture an impervious lining and can wash fine material from below up through a pervious lining. Specifications for reverse filter material proposed by Terzaghi as a means of preventing piping under dams provided a clue to a way of designing erosion-proof pervious linings. Preliminary tests showed that channels could be protected by using layers of successively coarser materials, each having a reverse-filter relationship to the layer below, continuing up to material heavy enough to resist being moved by the current. The question remained, however, as to whether erosion was really stopped, or merely slowed down so much that it could not be detected.

The final set of tests was planned to subject different erosion resistant installations to the attack of a turbulent jet, constant in intensity and severe enough to cause rapid failure if the protection was not good. The jet plunged into a pool 6 to 7 inches deep with a velocity of 14.4 ft/sec, at an angle of 50° with the horizontal, and close behind the glass side of a 1 by 1 by 2-foot tank. It was capable of moving rocks up to about the 1¼ inch size. A double or triple layer of rocks, carefully placed by hand to protect fine material, was undermined rapidly from the instant the jet was turned on. When thicker layers of rocks of varying sizes were used, the rate of failure was found to be little affected by the total thickness but greatly affected by the degree of departure from the Terzaghi specifications. If the specifications were met by the successive layers, no erosion could be detected even after long continuous runs. The total thickness could then be very thin, as each reverse filter layer had only to be two or three grain diameters thick.

Tests were also made with the top layer covered, not with large rocks, but with pea gravel bound in 1-inch diameter plastic mesh tubes. Again, there was no sign of failure after long runs but rapid failure if the inverted filter specifications were not met. The results of the tests are described in detail in "Erosion Prevention Experiments," Proceedings of the 13th Congress of the International Association for Hydraulic Research, Vol. 2, pp. 211-219, 1969. Since it was felt that the results would be of most interest to maintenance men and designers, who may not read technical papers, a 30-minute 16 mm color motion picture, "Erosion Protection," available from the University of Connecticut Audio-visual Production Department, was prepared. A condensed version of this film was shown at the "Water Resources Research 1970" Conference.

The experimental objectives have been accomplished and the project has been terminated.

PROJECT TITLE: A Study of the Legal and Administrative Practices Relating to Lake Pollution in the Northeast

PERSONNEL: Robert I. Reis, Paul Goldstein and William C. Kennard

DEPARTMENT: School of Law and Jurisprudence, State University of New York at Buffalo and Institute of Water Resources

PLANNED DURATION: July 1969 through June 1970

OBJECTIVES: To identify major legal problems relative to lake pollution in the Northeast United States, generally, and Connecticut, in particular; to establish basic criteria for consideration in the formulation of policies and methodologies for the enactment of legislation in the area; and to identify changes in statutory law and administrative structure needed to facilitate more extensive protection and utilization of inland lake waters

REPORT OF ACTIVITIES AND PLANS:

The primary purpose of the study was to determine the extent to which state legislative, administrative and judicial practices give recognition to the protection of lake water quality. Particular attention was placed on the control of phosphate and nitrate discharges as primary factors in the eutrophication process. It was assumed, initially, that other effluent discharges would be more easily controlled by single source legislative, judicial, or administrative practices. Phosphates and nitrates, on the other hand, are ubiquitous. Industrial wastes, municipal wastes, and general urban and agricultural runoffs contribute substantially to the amount of nutrients involved in the eutrophication process. New concepts must be established in order to control and distinguish between water quality and the preservation of lakes.

Our research procedure involved investigation of scientific literature on the aging process of lakes, specific effluents and their impacts on lake ecology, and other scientific materials which would define the extent of the factual problem for legal controls. At the same time, we investigated the state water legislation of all jurisdictions to determine whether their water quality standards recognized explicitly or implicitly lake water and whether these pieces of legislation could be used to control lake water quality. To the extent that they were available, local standards (administrative) were reviewed. Federal legislation, conference and prosecution practices, and all cases arising under state legislation were reviewed and analyzed in order to get a picture of where the current art of controls might lay.

We developed optimal models for comparison with the present legal control system. The purpose was to indicate the nature of needed controls, whether they would be available within the present system, what basic changes these needed controls required within the system, and what form model legislation would take. Models for phosphate and nitrate control require planned development, not only of specific municipal and industrial waste discharges, but of land use patterns around lakes and tributary streams and rivers. Depending upon the degree of nutrient control desired, the range of management possible extends from laissez faire to almost complete control of land use development as it might affect the ecological aspects of lake areas. Existing legislation does not provide the breadth necessary to approach the problem properly.

PROJECT TITLE: Variation in Diatom Morphology and Water Pollution

PERSONNEL: F. R. Trainor and M. E. Schultz

DEPARTMENT: Systematics and Environmental Biology Section, Biological Sciences Group

PLANNED DURATION: February 1967 through June 1971

OBJECTIVE: To correlate diatom structure and reproduction with chemistry of polluted waters

REPORT OF ACTIVITIES AND PLANS:

Diatoms are common organisms in fresh waters and in the ocean. Most are microscopic, live within glass walls and exist as unicells, simple colonies or chains. They are actively photosynthetic and are frequently dominant plants, especially in colder months.

Most people are familiar with diatomaceous earth, the remains of diatoms, actually their glass walls, which lived some 25 to 50 million years ago. Because of the permanence and the rigidity of the glass wall and the types of ornamentation found on diatom walls, classification of these organisms is based on wall structure. The symmetrical arrangement of holes, ridges, grooves, bumps and spines, which remain evident even after acid cleaning or ashing of specimens, has been used to erect a very rigid system of classification. For some time it was unpopular to examine living diatoms. Now we know that we must challenge this system of classification, not only because of our present understanding of the processes of organic evolution, but also because of diatom polymorphism, the condition in which the diatom can exist in two or more different forms.

A diatom wall is composed of two parts which fit together as a cover fits over a box. When Stoermer discovered a population of Mastogloia in which the upper wall could be described as one species and the lower wall a second species, we had polymorphism. We might also cite work with certain species of Coscinodiscus as well as the Nitzschia-Hantzschia complex.

Because new diatom walls, formed after division, always are located inside the mother walls, populations gradually diminish their cell diameters. With the Cyclotella meneghiniana strains we have isolated from the Connecticut River, we can follow these events in culture. When the cells are in the 6 micron range and they are subjected to increased levels of sodium, we can trigger the reproductive process. Some organisms produce flagellated cells (may be sperm), while others prepare to act as precursors to auxospores. The auxospore is an enlarged cell from which a new population of larger Cyclotella cells originates. Perhaps this reproductive phase is also triggered in nature, especially where there is increased sodium, e.g. near municipalities.

With Cyclotella cryptica, more commonly found in brackish waters, we can demonstrate polymorphism, e.g. it can be made to produce cells which resemble C. meneghiniana. The latter form appears to be correlated with growth at lower salinities, with C. cryptica types occurring where the total salt levels are increased. Since C. cryptica appears to be rare in Lake Michigan and found only in harbors or in inshore waters, we suggest that it might also occur in a C. meneghiniana-like form. (This form would be indistinguishable from true C. meneghinianas.)

With Cyclotella we thus have an organism which responds to changes in the chemistry of the water or culture solutions, either in form or in reproduction. Research is continuing and we should soon know whether it can be used to indicate either sodium levels or total salt levels of natural waters.

PROJECT TITLE: The Evaluation of Similarities of Algal Communities of Artificial and Natural Substrates

PERSONNEL: E. W. Hansmann

DEPARTMENT: Systematics and Environmental Biology Section, Biological Sciences Group

PLANNED DURATION: May 1969 through June 1972

OBJECTIVE: To examine the species composition and relative abundance of algal communities colonizing artificial substrates to determine whether they are indicative of the community found on the natural substrate of a stream

REPORT OF ACTIVITIES AND PLANS:

The German word Aufwuch has been applied to the community of organisms growing on free surfaces of submerged objects in the aquatic environment. These organisms include the primary producers (algae) and various micro and macro fauna. In streams, the Aufwuch community is found on stones, rubble, and other submerged objects; and, because of the physical characteristics of running water, primarily the current, this community virtually forms the basis of the primary producers of the ecosystem. Production of this community is closely related to the chemical composition of the water mass flowing over it. Consequently, an evaluation of the Aufwuch community has long been recognized as a means of evaluating stream biodynamics.

Because of the very irregular surfaces on which this community lives, quantifying parameters of the community have been difficult to develop. To circumvent this difficulty, man-made products of a given surface area (artificial substrates) are placed in the stream for a given exposure period during which time the natural community colonizes these substrates. These materials are then taken from the stream and the community that has colonized them is studied in terms of growth, production, succession, and species composition to determine whether it is indicative of the natural community in the stream. The validity of the results acquired by this technique has been questioned many times in the literature as well as by this author. Questions have been raised as to the length of exposure time necessary to give a good representative sample of the community, whether there is selectivity of substrate by the organisms, whether the position of the substrate affects colonization and whether production of the community on artificial substrates is similar to the natural substrate community of the stream. My research is concerned with looking into some of these questions as they affect colonization of artificial substrates.

Two of the three most common substrates used are being investigated, these being plexiglass and glass microscope slides. These are held in the stream with racks anchored to the stream bed. The glass substrates are held in the vertical, horizontal and surface positions and sampled after 18-day, 25-day and 40-day exposure periods. The plexiglass substrates are held only in the horizontal position. At the time of sampling, replicates of the three glass substrate positions and the plexiglass are removed and replaced with clean substrates. A sample of the natural rock community of the stream and, periodically, a sample of the tychoplankton are taken. These samples are brought to the laboratory and prepared for microscopic examination.

The objectives of this study are to answer the following questions: (1) Does the position of the artifical substrate affect colonization? (2) Does the length of exposure period affect the characteristics of the community? (3) Are replicate substrates similar in species composition and relative abundance? (4) Does the type of substrate affect colonization? (5) How does the community of artificial substrates compare to the natural community of the steam?

Results indicate that the primary difference between the community of artificial substrates and that of the natural substrate appears in the relative abundance of the organisms; but in some cases, species composition also varies.

PROJECT TITLE: Water Quality Control with Synthetic Polymeric Flocculants

PERSONNEL: J. K. Dixon, R. C. Tilton and J. Murphy

DEPARTMENT: Department of Chemistry (Torrington Branch) and School of Medicine

PLANNED DURATION: May 1967 through June 1970

OBJECTIVE: To measure the extent of flocculation of algae and bacteria in water by means of low concentrations of synthetic polymeric flocculants

REPORT OF ACTIVITIES AND PLANS:

Studies have been undertaken on the flocculation and settling of finely divided solids in water, particularly algae and bacteria, by adding low concentrations of synthetic polymers in order to improve water quality. The effects of polymer characteristics and quality of the water being treated have been studied.

The flocculation of algae and bacteria, which are finely dispersed in inland and coastal waters, was studied by determining the rate of settling of these finely divided biocolloids and/or by measuring the rate of filtration of the dispersed system since this rate increases markedly as flocculation occurs. Also, information on the charge on the solids was obtained by measuring the velocity of migration of the solids under the influence of an electric field (electrophoretic velocity).

It was found that the biocolloids flocculate rapidly upon addition of cationic (positively charged) synthetic polymers at concentrations of 0.5 to 100 ppm, the optimum value depending upon the pH, algal and bacterial concentrations, and the molecular size and structure of the polymer. Larger polymer sizes favored flocculation of both kinds of biocolloids, but pH was only important in the case of the bacteria (E. coli). When the concentrations of bacteria and algae were in the range from 40-1000 ppm, the bacteria were flocculated well by addition of 0.1-10 ppm of polymer, but the algae (Chlorella) required some 10 to 100 times higher concentrations of polymer.

The cationic polymers tested, which were quite similar to those made commercially and used extensively in actual plant operations, were effective for flocculation of algae, bacteria and silica; however, it was found that non-ionic polymers bearing no electric charge in solution were completely ineffective at concentrations of polymer from 0.01 to 100 ppm. Similarly, polymers which were negatively charged showed no flocculating power.

It is known that flocculation of colloids with polymers is often dependent upon the concentrations of divalent ions, such as magnesium and calcium, present in the system. It was conjectured that the relatively high concentrations of Mg ion required for algal growth systems, as compared with low concentrations in the bacteria, might have been responsible for the higher concentrations of polymer required for the algae; however, studies of Mg ion concentrations from 0 to 2500 ppm failed to show any influence on flocculation.

The experimental findings have been shown to be in accord with current theories of flocculation of many finely divided solids by high molecular weight synthetic polymers. Also, the results should serve to aid and guide the many practical applications of such polymers now in use. In order to improve basic and practical understandings of flocculation phenomena, the cationic polymers have recently been synthesized with tagged (radioactive) carbon so that the efficiency of flocculation can be related to the extent of adsorption of the polymers on the solids in systems containing silica, bacteria and algae. The effects of multi-valent ions on adsorption of polymer will be followed and the rate of flocculation, determined by particle size counting. The results will aid in the extension of the use of the polymers for water quality control.

PROJECT TITLE: Oxygen Status of Soil Air and Soil Water as Influenced by Oxygen Transfer Through the Soil Profile

PERSONNEL: R. William Wengel and Dale E. Linvill (Graduate Assistant)

DEPARTMENT: Plant Science

PLANNED DURATION: June 1967 through June 1971

OBJECTIVES: To characterize diffusion and transfer of oxygen through the soil profile under static and dynamic moisure conditions; to determine soil oxygen diffusivities as a function of soil water content; and to determine the oxygen status of soil water and soil air in the soil profile with regard to oxygen consumption within the soil profile

REPORT OF ACTIVITIES AND PLANS:

The zone of aeration in soils is of considerable importance in maintaining a suitable environment for the myriad chemical and biochemical reactions that take place at various levels within the soil profile. The type or nature of these reactions is largely dependent on the supply of oxygen throughout the profile over relatively long time periods, particularly those reactions involving decomposition of organic materials (e.g. solid wastes). This report is a summary of the results in characterizing the potential oxygen supply at various levels in the soil profile based on the oxygen demand (activity) at these levels and the soil oxygen diffusivity.

Four field lysimeters filled with Enfield fine sandy loam soil were used. Time based measurements of soil moisture content, soil oxygen concentrations, and soil temperatures were made at three depths in the soil over a two-month period during which soil moisture was varied by irrigation and oxygen demand varied through natural temperature changes. The data obtained were later used in calculations of activity factors in the solution of a diffusion equation for prediction of soil oxygen concentrations at various depths in the soil profile. After terminating field measurements, undisturbed soil core samples were obtained from the lysimeters for determining the relationship between oxygen diffusivity and air space porosity. Soil cores were mounted on a diffusion chamber apparatus and flushed with nitrogen gas to remove oxygen. Oxygen concentration-time curves were established at various soil moisture levels. Analysis of the data showed three distinct layers in the soil profile (0-8 cm, 8-40 cm, and 40-48 cm) with respect to oxygen diffusion. Within these layers diffusivity could be described by a single equation over a wide range of soil porosities: $D'/D_o = \gamma E^{\mu}$, where E is the porosity and μ is dependent on the nature of the pore space (tortuosity and continuity). It was found that D' required long time measurements of oxygen diffusion through the soil core for accuracy. Boundary conditions, particularly zero oxygen in the soil core, could not be fully met; hence, short term measurements led to large errors in D'. By determining D_e (effective diffusivity) from the slope of the oxygen concentration-time curve, D' could be calculated. D' values were about an order of magnitude lower for undisturbed soils than published values for artificial soil cores.

Oxygen consumption rates were determined using field data and diffusivity-porosity relationships. Assuming short term equilibrium, measured consumption rates agreed well with calculated values showing that oxygen supply potential at given depths in the soil can be determined by soil moisture, temperature and bulk density measurements once the soil oxygen diffusivity is known.

The research has been terminated and manuscripts are being prepared for publication.

PROJECT TITLE: Relative Pollution Strengths of Undiluted Waste Materials Discharged in Households and the Dilution Water Used for Each

PERSONNEL: R. Laak and J. C. Huang

DEPARTMENT: Civil Engineering

PLANNED DURATION: July 1969 through June 1971

OBJECTIVE: To gather basic information so that various redesigns of a household wastewater disposal system could be feasible.

REPORT OF ACTIVITIES AND PLANS:

Subsurface sewage disposal systems for individual households are rigidly controlled to protect public health. Increasing demands for housing have depleted the supply of suitable land which meets the soil conditions required for the present disposal system criteria. In order to redesign or improve the present method of wastewater disposal, basic data which are not now available are being gathered.

We are measuring the wastewater flow from each plumbing fixture by installing counters in toilet flush tanks, reading the water meters, recording the number of laundry loads, and by measuring the volume of each sink, tub, and fixture. A continuous survey is being kept on the number of pounds of each material wasted through the plumbing fixtures. The pollution strength is defined by the following analysis: BOD, COD, NH_3-N, NO_3-N and PO_4.

Preliminary results suggested the following conclusions:

a. The toilets contribute 40% of the sewage flow, 90% of the nitrogen compounds, 50% of the oxygen demand, and 23% of the inorganic phosphates.

b. The bathtub, showers and handwash basins contribute 40% of the sewage flow, 20% of the oxygen demand, and a negligible amount of nitrogen and phosphates.

c. The laundry washing activity contributes 10% of the sewage flow, 14% of the oxygen demand, 70% of the phosphates but a negligible portion of the nitrogen compounds.

d. The materials that showed a ratio of greater than five and less than ten between COD and BOD were detergent and boiled water used for vegetables.

e. The materials that showed a ratio of approximately ten or more between COD and BOD were tissue paper, liquid detergent, corn oil, ammonia compounds, and feces.

f. The ratio of total organic carbon to BOD indicated that if the ratio is more than one the material is resistant to rapid biodegradation.

Future plans are to confirm the preliminary data and include measurements on biodegradation rates, composite sampling of dishwash water, laundry wastes, bathtub water, etc. The results of these investigations will be incorporated into future research on backwashable seepage beds, soil's ability to infiltrate, and redesigned systems for household waste disposal.

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