

# *Selected Summaries of*

# **WATER RESEARCH**

Research and Development

Cincinnati Water Research Laboratory, Cincinnati, Ohio

OCTOBER 1967

## **NEW TREATMENT TECHNIQUES FOR WASTEWATERS**

Better treatment of wastewaters is needed now in some places and minimum treatment of effluents, just suitable for discharge, will not be satisfactory in the coming years. Treatment to make the wastewaters reusable for industrial, recreational, agricultural injection into the ground, and even supplemental domestic supply will become a necessity.

Various improved methods are discussed for removal of nitrogen and phosphorus, as well as physical-chemical processes, and reverse osmosis for advanced treatment to achieve full renovation of wastewaters. Cost estimates are given for the physical-chemical processes, and experimental results in demineralization by reverse osmosis are summarized.

Middleton, F. M., "New Treatment Techniques for Municipal Waste Waters," *Consulting Engineer*, 28:3, 137-141, 1967.

## **BLUE-GREEN ALGA**

The blue-green alga *Symploca muscorum* produces an earthy-smelling metabolite at an estimated concentration of 0.6 mg per liter of culture medium. The substance has been isolated by preparative gas chromatography and identified as geosmin on the basis of direct comparison with an actinomycete-produced standard. The results suggest that organisms other than actinomycetes are possible sources of earthy taste and odor problems in water supplies.

Safferman, R. S., Rosen, A. A., Mashni, C. I., and Morris, M. E., "Earthy-Smelling Substance From a Blue-Green Alga," *Environmental Science and Technology*, 1, 429-430, May 1967.

## **CHOLINESTERASE INHIBITOR**

Water and hydrosol samples were collected from the outfalls of chemical manufacturing plants, the Ashley River, and Charleston Harbor, South Carolina. These samples were analyzed for organic thiophosphate and organic chloride compounds by the use of column chromatography, gas chromatography, infrared spectroscopy, nuclear magnetic resonance spectroscopy, and mass spectroscopy. The combination of these analyses proved that the compound S,S,S-tributyl phosphorotrithioate, which is a cholinesterase inhibitor, was present in the effluent from one of the plants. This compound was formed naturally in the waste effluent by oxidation of S,S,S-tributyl phosphorotrithioite, which was manufactured at this plant.

Teasley, J. I., "The Identification of a Cholinesterase Inhibiting Compound from an Industrial Effluent," *Environmental Science and Technology*, 1:5, 411-416, 1967. (Reprints may be obtained from the Southwest Water Laboratory, Athens, Georgia 30601).

## **KLAMATH LAKE STUDIES**

This report defines the water quality in Upper Klamath Lake watershed during the period March 1965 to April 1966. It identifies the sources of algal nutrients and other constituents in water flowing into and out of Upper Klamath Lake and compares the quantity of these constituents in pristine streams, canals, rivers, agricultural drainage, and springs. Chemical analyses also made of algae, lake sediment, and bottom fauna samples. Algal species were identified and measured; during the period of the study *Aphanizomenon flos-aquae* represented about 90-99 percent of the total algal crop during the summer.

Miller, W. E. and Tash, J. C., *Interim Report, Upper Klamath Lake Studies, Oregon*, FWPCA Publication WP-20-8, 1967, 37 pp. (This report may be obtained from the Pacific Northwest Water Laboratory, Corvallis, Oregon 97330).

## URBAN DRAINAGE AND EUTROPHICATION

By the year 2000 some 240 million persons, 77 percent of an anticipated 312 million population in the 48 mainland states and the District of Columbia will occupy 22 intensely urbanized areas over the country, on about 11 percent of the area. These are shown on a map. Among them are three large regions identified as the Metropolitan Belt, extending across the northern states from the Atlantic Ocean to the Chicago area, the California Region and the Florida Region. Similarly mapped are the states and their numbers of communities which are wholly or partly served by combined sewer systems. Ninety-eight percent of these also lie in a band across the northern states from coast to coast, and including California. A third factor arises in that all three of the projected large urbanized regions abovementioned have tremendous potentialities for water recreation. The demand for this, and for the necessary water quality will be a sizeable challenge.

Tables showing average concentrations and computed annual amounts of constituents, including nutrients, produced per square mile by the several sources such as rainfall, community sewage, urban stormwater runoff and combined sewer overflows, based on studies at Cincinnati and information from the literature, are presented. These indicate that all are significantly concentrated in some respect as to warrant consideration in appraising sources of pollution, particularly nutrients. In terms of relative production of nutrients per unit of area, community sewage heads the group, followed in order of decreasing unit production by combined sewer overflow, stormwater runoff from a residential-commercial area and rainfall.

Urban stormwater runoff is considered by some to be a "resource out of place." The old rain barrel, and the cistern and pressure water system, are simple examples of this. Intercepted by roofs, parking lots, streets and other impervious surfaces, this water resource is conveniently distributed for possible storage and such practical uses as cooling, lawn and garden watering, recharge to ground, ornamental ponds, toilet flushing, delayed release to lower urban flood peaks, to name several. Selectivity or modification to reduce hazard should be examined, since storm runoff every source may not be suitable, nor hygienically safe, for all uses.

Comments on studies and practices representing the variety of efforts to control pollution from stormwater runoff or combined sewer overflows are presented. These include studies on settling, and on diversion of urban storm runoff to relieve lake enrichment, and ground recharge installations for road and housing development storm drainage. Those referring to combined sewer overflows include partial and complete separation of sewers, deep

tunnel storage, storage in sewers, and above-ground and below-ground storage-sedimentation tanks. Treatment of extraneous flows in sanitary sewers is also included.

Government research contract and demonstration grant programs to provide assistance to qualified workers interested in contributing to methods for control of storm and combined sewer sources of pollution are outlined.

Weibel, S. R., (Paper presented at the First International Symposium on Eutrophication sponsored by National Academy of Sciences — National Research Council, held at University of Wisconsin, Madison, Wisconsin, June 11-16, 1967.)

## IMPOUNDMENTS AND WATER QUALITY

This paper summarizes research in two categories: (1) investigative, designed to better understand impoundment behavior, and (2) engineering, designed to control impoundment water quality.

In the former category, studies are described concerning behavior of synthetic organics in stratified impoundments, determination of the influence of various naturally occurring environmental factors on the nitrification reaction, how to predict nitrification, and the role of algal photosynthetic production of oxygen, and atmospheric reaeration in the DO budget of lakes and reservoirs.

Streamflow regulation for water quality control, a scheme in which good quality stored water is released at times of low streamflow as a means of diluting and thereby improving water quality, has been under active consideration in this country over the past several years. While reservoir releases have long been used to supplement mainstream water quantity, their use specifically for quality control has been limited to date. To be successful, any streamflow regulation scheme is predicated on the availability of good quality discharges from the storage impoundment. If poor quality water is discharged into the main stream, deterioration of mainstream quality occurs and the water quality control scheme fails.

Various means of artificial destratification are also reviewed, including by pumping cold bottom waters and discharging them to the surface, and by an air diffusion system.

Symons, J. M., Irwin, W. H., DeMarco, J., and Robeck, G. G., *Effects of Impoundments on Water Quality: A Research Summary*, Bulletin of Engineering and Architecture No. 57, School of Engineering and Architecture, University of Kansas, Lawrence, Kansas, 28-36, 1967.

## PESTICIDE DEGRADATION

A knowledge of the movement and degradation of pesticides in natural water environments is important in evaluating their pollutorial potential. Anaerobic as well as aerobic environments must be considered since pesticides, in general, are strongly adsorbed to particulates which may settle into anaerobic muds and bottom waters of reservoirs, lakes, and slow moving rivers and streams.

This study was concerned with the degradation of selected chlorinated hydrocarbon pesticides under varied conditions in both anaerobic and aerobic environments. The rate of degradation of the injected pesticides was found to be both qualitatively and quantitatively different in the two environments; contrary to widespread opinion, degradation of chlorinated hydrocarbon pesticides was generally more rapid under anaerobic than under corresponding aerobic conditions. Especially remarkable was the rapid anaerobic conversion of DDT to DDD contrasted with the long persistence of unchanged DDT in similar aerobic environments. Equally remarkable was the somewhat slower but clearly observable degradation of lindane to unextractable products under anaerobic but not aerobic conditions. Heptachlor and aldrin also disappeared anaerobically; but heptachlor first changed rapidly to several intermediates, the most prominent of which was a fairly persistent, probably more reduced product that eluted between heptachlor and lindane on a gas chromatographic column. Dieldrin was by far the most persistent pesticide studied; heptachlor epoxide was slightly less persistent; but endrin was fairly degradable under anaerobic conditions.

In order to avoid many of the uncertainties of identification and problems of control so common to many field tests, this investigation consisted of a series of well defined laboratory experiments using known amounts of given pesticides. Analyses were performed using both microcoulometric and electron capture gas chromatography after suitable extraction and clean-up procedures. Degradation was considered complete when identifiable pesticide peaks could no longer be observed on the chromatographic charts. Some of the parameters studied in addition to anaerobic *versus* aerobic conditions included temperature, suspended solids, autoclaving, heavy-metal poisoning, and continual *versus* slug dosing with pesticides. The most significant results are, however, the demonstration of the importance of the anaerobic environment in the degradation of resistant pesticides.

Hill, D. W. and McCarty, P. L., "Anaerobic Degradation of Selected Chlorinated Hydrocarbon Pesticides," *Journal Water Pollution Control Federation*, 39, 1259-1277, August 1967. (Reprints may be obtained from the Southwest Water Laboratory, Athens, Georgia 30601).

## ANIONIC DETERGENTS

Six months before the date set for full-scale introduction of biodegradable anionic detergent to the consumer market (June 1965) a monitoring program was started on five municipal wastewater treatment plants. The purpose of the sampling program was to observe subsequent changes in the qualitative and quantitative portion of the methylene blue active substances in wastewater and treatment plant effluent.

The results of an 18-month study of the five plants show very little change in the concentrations of M.B.A.S. received in the raw wastewater.

No specific day-by-day correlation of M.B.A.S. removal with COD removal could be made. A general correlation was that the plants that removed COD most efficiently also showed greater efficiencies for M.B.A.S. removal. The removals of M.B.A.S. are lower than COD removals.

A decided change was noted in the qualitative make-up of the M.B.A.S. component of the raw wastewater. As a generalization, from the data from all five plants, it has been shown that prior to July 1965 raw wastewater contained about 40 percent M.B.A.S. resistant to biological degradation. After this date the resistant M.B.A.S. was found to be about 20 percent.

Barth, E. F. and Ettinger, M. B., "Anionic Detergents in Wastewater Received by Municipal Treatment Plants," *Journal Water Pollution Control Federation*, 815-822, May 1967.

## ESTABLISHING TOXICANT LIMITS FOR FISH

Two 10-month exposures of malathion and butoxyethanol ester of 2,4-D under continuous-flow conditions were made to determine the effect of these pesticides on reproduction and growth of fathead minnows, *Pimephales promelas* Rafinesque. Results show that 1/45 and 1/19 of the 96-hour median tolerance limit ( $TL_m$ ) concentrations of malathion and butoxyethanol ester, respectively, will not harm growth and reproduction of fathead minnows during continuous exposure. We suggest that these two fractions applied to  $TL_m$  concentrations determined for other species and other types of water should estimate accurately safe concentrations for other fishes to these pesticides.

Mount, D. I. and Stephan, C. E., "A Method for Establishing Acceptable Toxicant Limits for Fish — Malathion and the Butoxyethanol Ester of 2,4-D," *Transactions of the American Fisheries Society*, 96:2, 185-193, April 1967.

## MEASUREMENT OF FLOC STRENGTH

This study has provided some insight into the dynamic nature of flocculation, and a qualitative estimate of the tendency of floc to fragment or reform.

Floc formed in a Couette mixer were fragmented by a reproducible shear as they were drawn toward the aperture of an electronic particle counter. Numbers and sizes of floc fragments were counted as they passed through the aperture. Apparent floc strength as determined by flocculation rate, sizes of particles subjected to shear, and completeness of incorporation of small particles into a chemical floc, was shown to be affected by changes in pH, coagulant dosage, suspended solids, coagulant aids, and polyphosphate. The following conclusions were drawn:

1. The highest rate of flocculation does not necessarily produce a floc most resistant to shear.
2. Alum floc alone is relatively weak and is apparently strengthened by incorporating solids into the floc.
3. Sodium tripolyphosphate, if present when alum is added, may completely inhibit flocculation, but only slowly disperses an already formed alum floc.
4. The coagulant aids have a pronounced effect upon the formation of large strong floc, but limited dosages must be employed, as floc strength must be tailored to fit the overall treatment process. This includes filtration, which may be adversely affected by a very high floc strength.

Hannah, S. A., Cohen, J. M., and Robeck, G. G., "Measurement of Floc Strength by Particle Counting," *Journal American Water Works Association*, 59:7, 843-858, 1967.

## PHOSPHORUS REMOVAL

Phosphorus removal of 20 to 30 percent up to 70 to 90 percent have been noted in municipal wastewater treatment plants. The interaction of the mineral composition of the wastewater and biological synthesis could explain many of these varied removal efficiencies. This study employed supplementing the aeration chamber with materials known to form slightly soluble compounds with phosphate, and the elimination of digester supernatant feedback. With no mineral additive, 40-percent removal was obtained. With additives the range was 50 to 90 percent; aluminum and calcium gave the upper removal value and ferric chloride ( $\text{FeCl}_3$ ) gave the next highest value, 75 percent, as did calcium plus fluoride.

Barth, E. F. and Ettinger, M. B., "Mineral Controlled Phosphorus Removal in the Activated Sludge Process," *Journal Water Pollution Control Federation*, 39, 1362-1368, August 1967.

## NITROGEN CYCLE IN WATER

This study was designed to demonstrate the influence of environmental factors on the rate and extent of nitrification, an important consideration in any evaluation of projects involving impoundment of waters for streamflow regulation. Nitrogen balance was attained in a clean, aerobic system by measuring only three of nine possible valence states of nitrogen, using an automated procedure for nitrogen analyses. Factors influencing ammonia oxidation and oxidation of ammonia nitrogen were reported, including effects of the presence of organics. Bacterial counts were correlated with chemical changes to obtain a method of evaluating the nitrification potential of a given environment. Attempts to develop a predictive tool for evaluating the nitrification potential were unsuccessful because of the low efficiency of counting and length of time required for enumerating the nitrifying populations.

DeMarco, J., Kurbiel, J., Symons, J. M., and Robeck, G. G., "Influence of Environmental Factors on the Nitrogen Cycle in Water," *Journal American Water Works Association*, 59:5, 580-592, 1967.

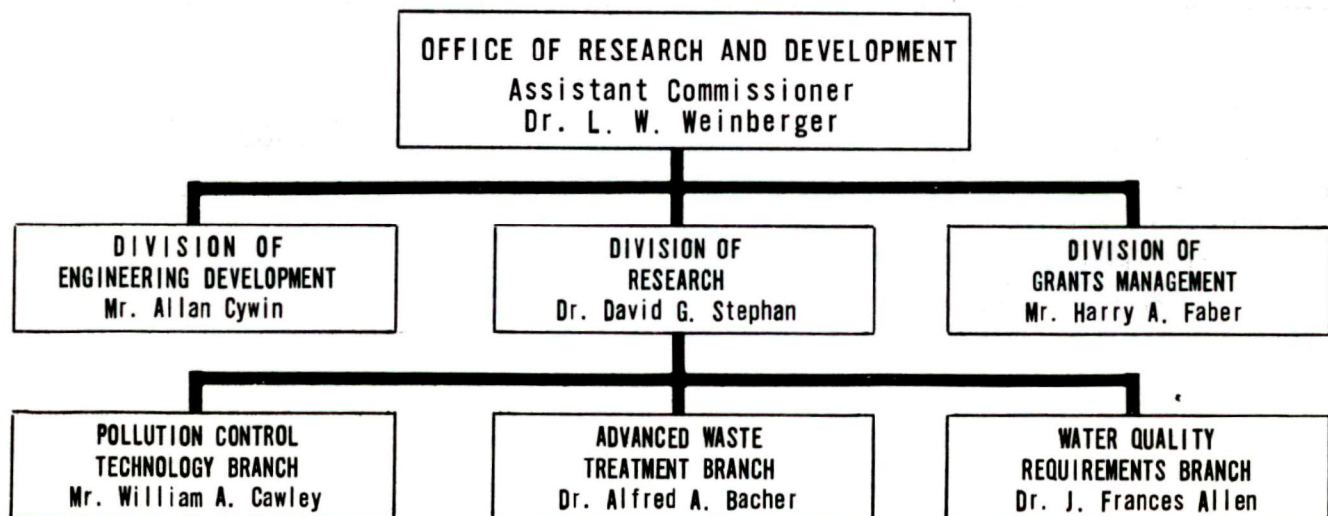
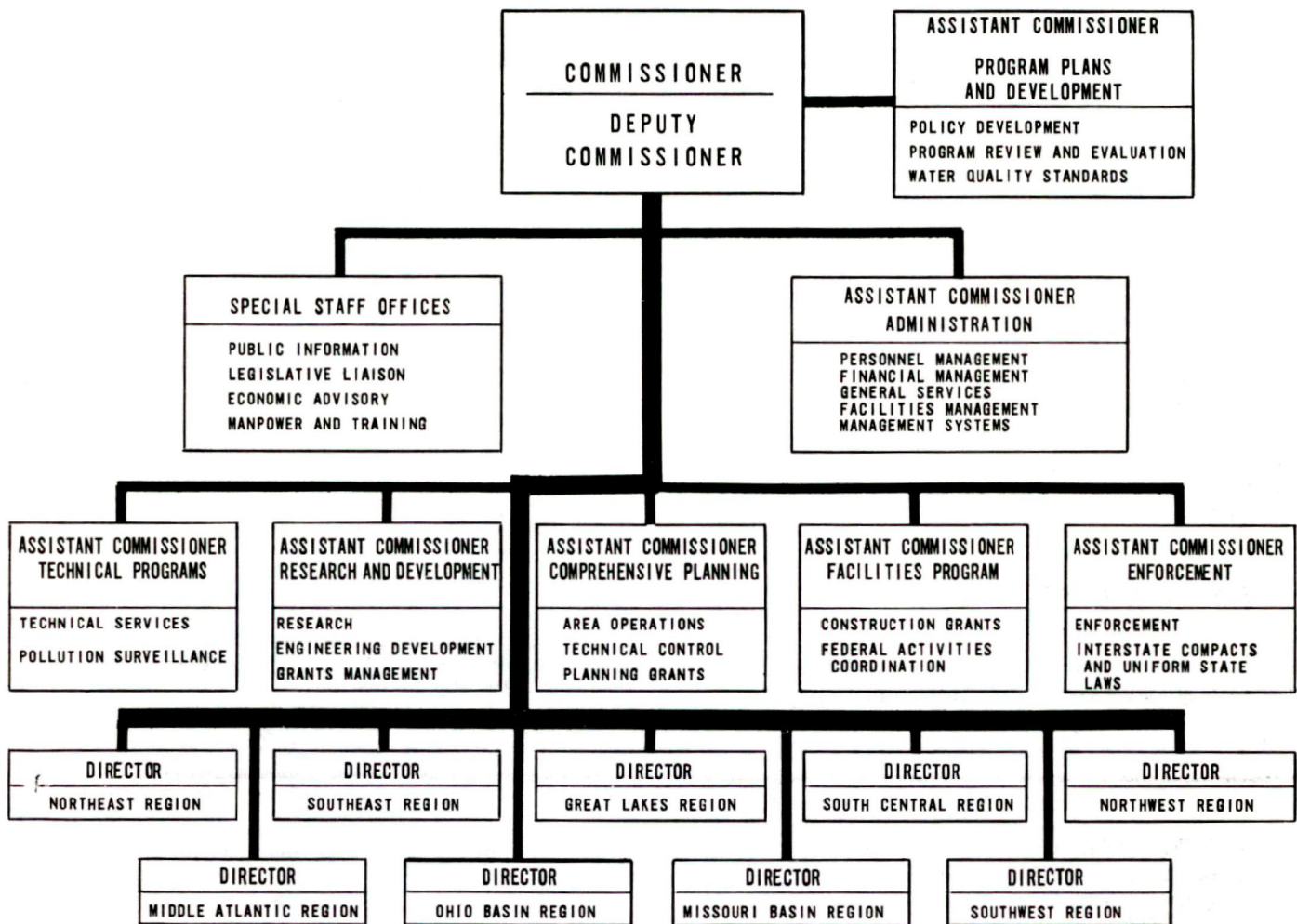
## PERSISTENCE OF SILVEX

The propylene glycol butyl ether ester of silvex, an herbicide useful to control aquatic plants, hydrolyzed almost totally of silvex acid in about two weeks when applied at the rate of 8 lbs/acre (acid equivalent) to water overlying Cecil sandy clay loam, Lakeland loamy fine sand, and Brighton muck soils in plastic pools. Silvex acid increased in concentration in water for a week and then dissipated gradually over a 19-week period. Apparent adsorption of both the ester and acid occurred on the hydrosol and was followed by gradual diminution of both. Laboratory studies confirm that silvex acid can be adsorbed by the three soils. The possibility exists that silvex acid and/or a degradation product may be desorbed and readmitted to water.

Limiting nutrient studies using the isotope Carbon-14 to measure variations in primary productivity were conducted *in situ* and in the laboratory; data from these studies were difficult to interpret.

Cochrane, D. R., Pope, J. D. Jr., Nicholson, H. P., and Bailey, G. W., "The Persistence of Silvex in Water and Hydrosol," *Water Resources Research*, 3:2, 517-523, 1967. (Reprints may be obtained from the Southwest Water Laboratory, Athens, Georgia 30601).

# FEDERAL WATER POLLUTION CONTROL ADMINISTRATION ORGANIZATION



## MEMBRANE FILTER PROCEDURE

The membrane filter procedure will yield accurate and reliable results when it is carried out by experienced people using accepted materials and procedures. This method, however, does require more skill and personal judgment than are necessary for the MPN test. There will be occasional water samples, with their great variety of pollutants, for which the MF procedure should not and cannot be used. In such instances, the multiple tube technique is the method of choice. However, the MF technique can be and is being used on a routine basis by many water laboratories. It must be understood that more attention should be paid to proper MF methodology. With proper care as to size of sample, medium preparation, time and temperature for incubation, and colony sheen discernment, the MF is an excellent bacteriological tool capable of yielding a more precise and rapid answer than is available from the multiple tube MPN test.

Geldreich, E. E., Jeter, H. L., and Winter, J. A., "Technical Considerations in Applying the Membrane Filter Procedure," *Health Laboratory Science*, 4:2, 113-125, April 1967.

## MEASURING FECAL POLLUTION

Data have been collected on the amounts of coprostanol and cholesterol in treatment plant efflu-

ents and surface waters. The data show a definite increase in the concentration of fecal sterols in streams below a wastewater treatment plant outfall. The specific nature of coprostanol and its occurrence in surface water subject to fecal pollution leave little doubt that the presence of this sterol in water indicates fecal pollution.

The detection method is adaptable for field survey use in mobile trailers or in temporary laboratory facilities. Results can be obtained on the day a sample is taken. The labor cost of each analysis would be about double that for bacterial detection if we assume two men could do 24 samples per day biologically as opposed to only 10 per day chemically.

Coprostanol can be detected in water at a concentration of 20 ng/l (0.02 ppb) and quantitative measurements are possible above 100 ng/l (0.1 ppb). This sensitivity is comparable with the microbiological method of detecting fecal coliforms. This statement is based on the fact that human feces average  $2 \times 10^9$  fecal coliform bacteria and  $2 \times 10^9$  ng of coprostanol per day per capita. Thus, the finding of two coliform bacteria in 100 ml would be equivalent to detecting coprostanol in the extract from 2 liters of water.

Murtaugh, J. and Bunch, R. L., "Sterols as a Measure of Fecal Pollution," *Journal Water Pollution Control Federation*, Part 1, 404-409, March 1967.

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