A Critical Review of the

Literature of 1957 on Water Pollution

Prepared for the Research Committee
of the
FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS

January 1958

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

A CRITICAL REVIEW OF THE LITERATURE OF 1957 ON WATER POLLUTION

by

M. B. Ettinger
W. M. Ingram
P. W. Kabler
M. Katz
F. W. Kittrell
R. Porges
C. M. Tarzwell
W. W. Towne
E. C. Tsivoglou
R. L. Woodward

Prepared for the Research Committee
of the
FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS
January 1958

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Public Health Service

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

INDEX

		Page
1.	Biology	1
2.	Microbiology	33
3.	Chemistry	41
4.	Oxygen Sag and Stream Self-purification	44
5.	Stream Studies and Surveys	52
6.	Stream Standards	57
7.	Effects on Water Supplies	59
8.	Abatement and Control	60
9.	References	65

A CRITICAL REVIEW OF THE LITERATURE OF 1957

ON WATER POLLUTION

by

M. B. Ettinger, W. M. Ingram, P. W. Kabler, M. Katz,
F. W. Kittrell, R. Porges, C. M. Tarzwell, W. W. Towne,
E. C. Tsivoglou, and R. L. Woodward

BIOLOGY

Pollution Surveys and Investigations

Cooperative state-industry stream studies are being carried out on several rivers of Wisconsin (204). Chemical, physical, and biological conditions in the Fox River below Lake Winnebago, were studied intensively. It was found that some stretches of the river may receive as much as 400 tons of organic matter per day; that sludge deposits are formed, and that in some sections D.O. is reduced to critical levels. Graphs of D.O. concentrations indicate that lethal levels for fishes are reached in one area.

A Fish and Wildlife Service report (184) points out that pollution of the Delaware River in the Philadelphia area prevents its use by shad as a spawning and nursery area. Pollution has been most severe on the runs of shad in recent years, affecting spawners during the upstream migration and both young and adults on their downstream migration. The Delaware River fishery for shad has declined from a peak production of 19,000,000 lbs. in 1896, to a level at which it is economically unfeasible for fishermen to operate. Apparently the decline is due primarily to an

oxygen block between Torresdale and Marcus Hook where the D.O. falls to zero or near zero in the late summer. The period of low flow, low D.O., and downstream migration of juvenile shad occur simultaneously in September and October. There is also a high mortality of spawned out fish as only 1.7 percent of adults are repeat spawners while in other Middle Atlantic streams the percentage is 34.6 to 51 percent.

Many statewide surveys are being carried out through the use of Dingell Johnson funds. These serve to indicate the condition of streams and of fish populations. Hulsey (86) reports that the Red River watershed is the most seriously polluted area in Arkansas. Oil field wastes pollute 415 miles; silt and shifting sand pollute 136 miles, paper mill wastes, 110 miles, phenolic compounds, 25 miles, and barite mine seepage waters, 20 miles. The Arkansas River watershed is the second most polluted with silt and shifting sand being the main pollutant. In the Russell and Levisa Forks of the Big Sandy River in Kentucky, pollution is due to coal washings, acid mine waters, sewage, oil, silt, and sawdust. In some sections of the streams coal deposits are four feet deep (101). Electric seining operations indicated that 45 species of fish were present in these streams.

A survey of the Bhadra River of India (45) indicated extensive biological effects of industrial pollution. Fish found dying below paper mills had not been feeding as their digestive tracts were empty. A strong, mixed odor of sulphides, sulphonates, and chlorine emanated on opening these fishes. Heavy sewage pollution in the Schliersee brought about a deterioration in condition and a decrease in numbers of the fish (169).

The fish which were examined showed signs of starvation. Vivier found that a rayon plant on the Somme increased the mineral content of the stream and encouraged slime growths which at times broke loose and caused sudden fish kills (196). The discharge of organic wastes into lakes brought about a decrease in the oxygen content of the deeper waters and caused the near disappearance of salmon in Lake Eguzon and Annecy. Lake Leman is affected most by the sewage of Lausanne which has caused a putrid slime deposit on the bottom about 60 cm. deep.

Hawkes (75) presents and illustrates the use of a biological method of classifying the pollution of streams. He stresses the need for complementary biological and chemical examinations in all surveys of pollution and points out that biological examinations have shown rivers to be seriously polluted by toxic substances which were only subsequently detected by chemical tests that were not practiced on a routine basis. The Freshwater Biological Association (British) in its 23rd Annual Report describes its continuing studies of pollution and the aquatic environment (8). These studies deal with water movements in stratified lakes, the source of dissolved solids, factors governing the abundance of algae, composition of lake muds, and population studies of fishes and invertebrates.

In Great Britain there are several river boards which make annual reports on their surveys and investigations. These reports contain much valuable information on the effects of pollution and the benefits of various abatement methods. In their 1956 report (5) the Bristol Avon River Board gives information on water use, floods, waste discharges, pollution abatement, stream classification, waste treatment, fisheries,

and toxicity.

Reports on pollution abatement and research activities in several areas were made at the Seminar on Biological Problems in Water Pollution at the Robert A. Taft Sanitary Engineering Center and are included in the Transactions of the meeting. Research activities in Great Britain were summarized by Beak (17) who pointed out that the research program is shaped to meet the requirements of the 1951 River Pollution Prevention Acts with special emphasis on standards of purity to be established. One team has been carrying on fundamental research on the toxicity to fish of various chemicals, particularly CN, CO_2, and ammonia. Another team has been carrying on field studies of pollution biology, particularly as pertains to fishes. In Ohio, the Division of Wildlife is responsible for the protection and preservation of wildlife and thus the majority of their studies are concerned with fish kills. An intensive study is being made of the effects of acid mine drainage in the Racoon Creek basin and possible corrective measures are under test. Studies are under way on the Little Miami River to determine improvements, resulting from sewage treatment (158).

In British Columbia, studies of the effects of wastes from forest products industries on the marine environment are being stressed (198). In Ontario, the most intensive investigation has been on the Spanish River where it was found that the deposition of wood fibers was of prime importance in the elimination of fish food organisms over an extended area (141). The mining industry has also created problems due to ore pulverizing wastes which have produced turbidity and unstable bottom conditions. The mining of uranium ores has added new problems; namely,

highly acid wastes and toxic metals. Methods for the control of blue green algae by the removal of phosphorus have been developed and tested. Routine stream surveys are now complete in Wisconsin and more intensive studies are now being made on the major waterways. These have indicated that studies during the winter period are of importance (129). A cooperative program of investigations in water pollution biology is being carried out by the Dept. of Fish and Game Management of Oregon State College and the Robert A. Taft Sanitary Engineering Center of the Public Health Service. Complementary field and laboratory research designed to provide basic information on pollutional problems in fresh and marine waters is under way. Current field studies include physical, chemical, and biological investigations of polluted streams and studies of small streams, experimentally subjected to controlled pollution. Artificial stream studies are being used to evaluate the effects of low level pollution and studies are in progress on the influence of D.O. upon the survival, development, growth, activity, and movement of fresh water fishes (200). The relation of the various fish and game programs of the Fish and Wildlife Service to the pollution problem was described by Meehan (131). Acid mine drainage, mining wastes, oil pollution, lumbering operations, pesticides, water development projects, and domestic and industrial wastes all may have adverse effects on large segments of wildlife populations. In the Missouri Basin wastes from the processing of agricultural products are the main pollutants. Other sources of industrial wastes are oil fields, refineries, steel mills, and chemical plants. An unusual fish kill in the Yellowstone was directly occasioned by aerial

spraying with DDT to control spruce budworm in the headwater areas (140).

Additional References

1. Pentelow, F. T. K., "The Biology of Rivers in Relation to Pollution." Pub. Health Eng. Abs., 36, 11, 18 (1956).

2. Olson, T. A., "Biological Indicators in Stream Ecology." Proc. 11th Ind. Waste Conf., Purdue Univ. Series No. 91, 601 (1957).

Fish Kills

The use of a 30 percent DDT concentrate in an emulsifiable oil with 0.5 percent "Lissapol" as a spray to control *Tanytarsus lewsii* in the Nile above Khartoum, resulted in an extensive fish kill. *Labea* were killed in 8 hours and *Synodontis* in 36 hours (24). Low oxygen levels during the night and early morning hours due to excessive growths of aquatic vegetation were responsible for heavy fish mortalities in Madras State (30). A similar kill in a temple tank resulted from a heavy growth of *Microcystis aeruginosa* (193). Methods for the investigation of fish kills and steps to be taken when such a kill occurs are outlined by Liebmann (117). In their "Fish Conservation Highlights of 1956" Stroud and Seaman list damage to fish populations throughout the country by various pollutants. Insecticides are becoming of increasing importance in fish kills (181).

Water Quality Criteria for Aquatic Life

General

Since the purpose of water quality criteria for aquatic life is to maintain conditions which are favorable for aquatic organisms they must be based on knowledge of the environmental requirements of these organisms. While much is known concerning the environmental requirements of the aquatic biota much remains to be learned. Ecological, life history, and environmental studies are, therefore, pertinent and valuable. Studies carried out in Belgium have lead to the conclusions that: alkaline waters are most favorable for fishes; the optimum pH is between 7.0 and 8.0 although values of 5.0 to 9.0 are tolerated; water passing over granite rocks is usually acid and not favorable for breeding; D.O. content is very important and should be fairly stable throughout the year; trout require more oxygen than do carp and tench, and the optimum water temperature for trout breeding is 15° to 17° C. and for carp, 20° to 25° C. (85). A study of mayflies in Douglas Lake, Michigan, has shown that Hexagenia nymphs are limited by the oxygen concentration to that portion of the mud bottom above the level of the hypolimnion (125).

In a general discussion of the subject, Tarzwell (185) states that while much remains to be learned, enough information is now at hand for the setting of tentative criteria. It is suggested that pH values should not fall below 5.0 or exceed 9.5, but for good production they should be maintained between 6.5 and 8.5; that for Salmonoid fish 6.0 p.p.m. of D.O. is desirable; that for a well rounded warm water fish population, D.O.

levels should not fall below 5.0 p.p.m. for more than 8 hours out of a 24 hour period, and at no time should they fall below 3 p.p.m. while for coarse fishes they may drop to 2 p.p.m.; for warm water fishes temperature should not exceed 93° F. in the northern portion of the country or 96° F. in the south, and for trout best production is obtained in streams having summer temperature of 60° to 68° F. It is suggested the amount of toxic wastes which can be added to a specific stream should be determined in each case by means of bio-assay.

Suspended Solids and Turbidity

Studies in Oklahoma (23) revealed that high turbidities reduced the growth and yield of bass and bluegills and favored the production but not the growth of channel catfish. Clear reservoirs attracted more anglers and yielded greater returns per unit of fishing effort as well as more desirable species of fishes. Experiments in clear ponds, turbidities less than 25 p.p.m., intermediate ponds, turbidities from 25 to 100 p.p.m., and muddy ponds, turbidities over 100 p.p.m., showed that the average total weight of the fish in the clear pond was 1.7 times that from the intermediate pond and 5.5 times that from the muddy pond. Wilson (207) reviewed the literature on the destruction of aquatic life by turbidity and silt and presented evidence of lowered productivity due to the screening out of light and the abrasive and smothering action of sediment on the bottom fauna and fish eggs.

Temperature

Experiments to determine the effects of temperature on the respiratory movements of carp indicated that the upper lethal temperature

is lower for the older heavier carp than for the smaller younger fish which showed little change in respiration rate over a temperature range of 15° to 35° C. (134). Experiments with guppies have shown that in fresh water the optimum temperature range for growth is 23° to 25° C. and that growth in 25 and 50 percent sea water is greater than in fresh water (65). The upper temperature threshold for the normal development of Chinook Salmon eggs was found to be 57.5° to 60° F. while the lower threshold was 40° to 42.5° F. (37). It has been experimentally demonstrated that lobsters can be acclimated to certain temperatures, acclimatization for transfer from 14.5° C. to 23° C. being completed in 22 days. Moulting lobsters are less resistant to high temperature, low salinity, and low D.O. than are hard-shelled lobsters. The upper lethal temperature was raised by an increase in thermal acclimatization, lowered by a decrease in the level of oxygen acclimatization, and lowered by acclimatization to reduce salinity (128).

Dissolved Solids and pH

Since the war industrial plants on the Werra River of Germany have been discharging large amounts of chlorides and have brought about fish kills in 1949, that were positively correlated with the increase in the salt content of the river water. Fish that were moribund recovered when placed in polluted water that was diluted 30 percent with tap water. Fish kills occurred in winter when the salt content exceeded 12,000 p.p.m. The next spring surveys showed that fish were absent from the river immediately below the industrial concentration. The resistance to salinity

is greater at lower temperatures. The insect larvae disappeared from the more saline regions and there was a reduction of fish food organisms (170). A year round study was made of a prairie stream polluted with brine wastes from oil wells and in which the concentration of chlorides ranged from 20,000 p.p.m. at the headwaters down to 100 p.p.m. The 34 species of organisms found in the stream throughout the year are arranged according to their chloride tolerance. Fish were present only in the section having chloride concentration of 100 to 1000 p.p.m. (34).

Additional References

1. Lofts, B., "The Effects of Salinity Changes on the Respiratory Rate of the Prawn Palaemonetes varians (Leach)." Jour. Exp. Biol., 33, 730 (1956); Water Poll. Abs. (Brit.), 30, 229 (1957).
2. Seume, F. W., "The Rearing of Daphnia magna." Anz. Schadlingskunde 30, 25 (1957); Chem. Abs., 51, 9953 (1957).

Dissolved Oxygen and CO_2

Experiments were carried out to determine the respiration of aquatic animals at different rates of flow and the relation of the lethal oxygen tension to the rate of flow and of the oxygen demand of larvae to the oxygen tension and the rate of flow (91). In experimental studies with caddis fly larvae, it was found that larvae normally inhabiting riffle areas are readily immobilized at a relatively high oxygen concentration in still waters but can tolerate low oxygen concentrations in flowing water comparable to levels tolerated by the species found in pool areas (152).

It was found that goldfish acclimated for several days to low D.O. levels, could withstand considerable lower D.O. concentrations than goldfish which had not been acclimated. The goldfish acclimated to low oxygen had increased hemoglobin and higher red cell counts and a lowering of the oxidative activity of some tissues (155). The maximum lethal concentration of D.O. for yellow perch during short exposure periods varied from 0.77 p.p.m. at 53° F. to 1.34 p.p.m. at 70° F., as determined by turnover in a sealed container (26). It has been shown that concentrations of CO_2 which sometime occur in polluted streams can more than double the minimum concentration of D.O. necessary for the survival of half the rainbow trout during a 24 hour exposure period. In solutions containing up to 67 p.p.m. CO_2, survival times are shortened by an increase in temperature from 12.5° to 19.5° C. (2).

Studies of winter kills on six southern Minnesota lakes lead to the conclusion that the dissolved oxygen level is the best basis for forecasting winter kills. High concentrations of CO_2, H_2S, and ammonia are concurrent phenomena of low oxygen conditions and are not the cause of the kills (172). In connection with a fish kill below a kraft pulping plant, field bio-assays were run to determine the toxicity of free chlorine (Cl_2) at different D.O. concentrations. It was found that 0.2 p.p.m. Cl_2 killed all the test fish at D.O. levels of 1.0 to 2.0 p.p.m. but did not kill fish at 5.0 p.p.m. D.O. (15). The resistance of several species of fish to low D.O. concentrations was tested at temperatures of 10°, 16°, and 20° C. Rise in temperature reduced the resistance of all species

tested to low D.O. Tench were the most resistant to low oxygen and in general trout were the most susceptible (48).

Additional References

1. Hishida, T., and Nakana, E., "Respiratory Metabolism During Fish Development." Embryologia, 2, 12, 67 (1954); Chem. Abs., 51, 15015 (1957).

2. Harts, J. S., "Seasonal Changes in Carbon Dioxide Sensitivity and Blood Circulation in Certain Fresh-Water Fishes." Can. Jour. Zool., 35, 195 (1957).

3. Fish, G. R., "Some Aspects of the Respiration of Six Species of Fish from Uganda." Jour. Exp. Biol., 33, 186 (1956); Water Poll. Abs. (Brit.), 29, 339 (1956).

4. Wittner, M., "Effects of Temperature and Pressure on Oxygen Poisoning of Paramecium." Jour. of Protozoology, 4, 1, 20 (1957).

5. Pentelow, F. T. K., Allan, I. R. H., Herbert, D. M. W., and Alabaster, J. S., "Sewage Effluents and Their Effect on Fish." The Surveyor, 116, 986 (1957).

6. Van Horn, W. M. and Balch, R., "The Reaction of Walleyed Pike Eggs to Reduced Dissolved Oxygen Concentrations." Proc. 11th Ind. Waste Conf., Purdue Univ. Series No. 91, 319 (1957).

Toxic Wastes

Methods: Bio-assay procedures are not in wide use for the determination of the toxicity of wastes and other materials to fish and other

aquatic organisms. Work is also under way to develop methods for using the results of short time tests to indicate safe concentration under conditions of continuous exposure. Studies are being made of a great variety of toxicants and the influence of various environmental conditions on their toxicity.

Burdick (25) suggests that the curvature found in logarithmic plots of concentration against time for death in toxicity studies is induced by failure of the effective range to conform to the axes of the paper. Translation may be effected by subtracting the threshold value from concentration and a minimum time from death time. When this is done the curve becomes a straight line and represents a simple inverse proportion. A graphical method is presented by which these corrections may be approximated and an equation for the original curve derived. The value of this procedure lies in the evaluation of the threshold concentration which may be used to establish safe disposal rates for toxic wastes.

Merkens has described an apparatus which can be used with very little manual attention to vary independently the temperature, pH, D.O., and concentration of toxicants in water supplied to six specially designed aquaria (132). Halsband developed a method for assessing the toxicity of substances in water through changes in respiratory rates. Fish are kept in a constant flow of water in a dark pipe. Their respiratory movements are measured by a new electrical method first in normal water and then after the addition of the toxic substance (71). As the result of tests carried out in Belgium, the value of bio-assays in assessing water quality

is discussed. It is concluded that fish toxicity tests are of use for determining the effect of a given effluent on fish in a river and the dilution or degree of treatment required to prevent fish mortality (111). A field technique has been developed whereby the concentration of sodium pentachlorophenate in natural waters can be determined by observing the mortality rate of the common guppy and comparing it with standard mortality curves developed for known concentrations of the material under conditions encountered in the field (102).

Henderson points out (76) that the toxicity of mixed industrial wastes cannot generally be estimated from chemical composition. It is necessary to conduct bio-assays with the mixed waste using for dilution the water from the receiving stream or water with similar characteristics. Further a numerical value called the application factor, must be developed and applied to the TL_m derived from short time tests to indicate safe concentrations for aquatic life under conditions of continuous exposure. In developing the application factor major consideration is given to relating the test to actual conditions, the test fish to other aquatic life, and to possible effluent fluctuations (76).

Garrett (61) points out that it is becoming increasingly important to obtain biological information on a waste problem and in many cases this information is as important as chemical and engineering data. Bio-assay data on wastes from a Monsanto Chemical Company plant were used in the design of waste treatment facilities. One-tenth of the 24 or 48 hr. TL_m was set as the effluent standard. In another article (62) the same

author points out that the most serious toxicity problem facing a manufacturing plant in providing for waste discharges is concerned with the effects on aquatic life. One of the principal reasons for this is that the appearance of dead fish in a receiving stream has long been considered the ultimate evidence of bad industrial practice.

The use and value of bio-assays in meeting toxic industrial waste problems, methods, equipment, supplies, procedures, and costs for carrying on bio-assays, and the use of bio-assay results in meeting specific problems are described by Henderson and Tarzwell (77). Several examples are given of the use of bio-assays by industry in the safe disposal of toxic wastes. Conventional physical and chemical tests of the effluent of a large synthetic fiber plant gave no evidence of serious pollution. Bio-assays showed this effluent to be highly toxic to fish under minimum river flow conditions and also helped to locate the major toxic component. Attention to the elimination of this material in the treatment process restored the aquatic life of the river in a short time. According to an article by Vinogradov (194) the sanitary authority of the U.S.S.R. is meeting toxic waste problems by limiting the concentration of certain substances which may be discharged. The limit for lead, copper, nickel, cyanide, and chromium is 0.1 p.p.m., and for other materials is as follows: picric acid, di- and tri-nitrotoluol, dinitrochlorobenzole, tetranitromethane, 0.5 p.p.m., mercury, 0.005, arsenic 0.05, carbon disulphide 1.0, fluorine 1.5, carbon tetrachloride 5.0, DDT 0.2, dinitronaphthalin 1.0, dichlorethane 2.0, and chlorine 0.0 p.p.m. This approach disregards the

quality of the receiving water, synergy and antagonism, wastes already present, and size of the receiving stream but gives strict and uniform regulations which are easier to enforce.

Tests indicate that the time of response of fish to Sarin decrease relative to decreases in the D.O. content of the water. Fish used in the studies were fathead minnows, green sunfish, and goldfish (203). The toxicity to Gambusia of 86 compounds which may occur in oil refinery wastes was determined by means of bio-assays. Because the waters of Oklahoma, which were of chief concern, are mostly turbid, bio-assays were conducted in turbid water. The results seem to suggest a protective action of the turbidity (199). For that or some other reason some of the results are at variance with those obtained by other workers. For some years bio-assay tests have been carried out in an effort to find a specific toxicant for the larvae of the sea lamprey, Petromyzon marinus, in the Great Lakes area. Tests were made with the lamprey, rainbow trout, and the bluegill. Of the 4,436 chemicals so tested, 264 were toxic to only one species and 333 were toxic to only two species (14). This work has lead to specific materials for the control of the lamprey larvae; namely, the Nitrophenols.

Metals: Extensive experimental studies of the effects of dilute solutions of toxic substances, discharged into the Kama River, on various types of river bottom animals indicated that 0.01, 0.002, and 0.001 normal solutions of $K_2Cr_2O_7$ were lethal in 25, 47, and 67 minutes respectively, to Daphnia pulex. Similar tests were made with $Pb(NO_3)_2$,

methyl violet, and other industrial wastes. Among other harmful industrial wastes are those from dye plants, coke plants, oil refineries, soda works, paint factories, and fertilizer works (187). It was found that a 5×10^{-4} M. sea water solution of uranyl nitrate inhibited the formation of the fertilization membrane in Urechis eggs and lead to polyspermy (103). These findings indicate that in determining the effects of toxic materials more than lethal effects should be considered. Experiments with chum salmon, Oncorhunchus keta, 3.9 to 5.8 cm. in length in salinities of 17.9 to 18.1 p.p.t., at temperatures of 14.4° to 15.0° C., and at D.O. level of 85 percent of saturation, indicated a 48 hr. TL_m value for As_2O_3 of 11 p.p.m. (4). There is now experimental confirmation of the hypothesis that metallic cations are toxic because they combine with an essential sulfhydryl group or a key enzyme. It is assumed that the affinity of the cations for the sulfydryl group is a linear function of the insolubility of the corresponding metal sulfide. Metal ions that form the most insoluble sulfides will also be the most toxic. Experiments carried out with distilled water indicate that the metals, listed in their order of toxicity are as follows: Ag, Hg, Cu, Cd, Pb, Zn, Ni, Co, and Mn (175). Experiments with fish spawn, young fish, and Daphnia showed that Zn plates placed in hard well water did not form poisonous salts but such salts were formed in soft water ponds which were toxic (154). Other experimental studies indicated that temperatures as well as hardness, influence the toxicity of Zn. In soft water the 96 hr. TL_m was 2.86 p.p.m. at 18°C. and 1.93 p.p.m. at 30° C. In hard water it was 10.13 p.p.m. at 18° C., and

10.15 p.p.m. at 30° C. (29). Bio-assays to determine the effects of various Cu and Hg compounds on Artemia salina, Elminius modestus, and Acartia clausi indicate that the latter two were more sensitive than Artemia to all the materials tested. The mercuric compounds were more toxic than Cu to Artemia. Mixtures of the two materials gave a synergistic effect. Exposure of Artemia to Cu rendered it much more sensitive to subsequent exposure to $HgCl_2$, but not to Cu. The opposite was also true (41). Additional studies demonstrated that the toxicities of primary alkylmercuric chlorides become considerably less when cystine and reduced gluthathione are added to the toxic media. In general, a good measure of agreement has been found between the relative lipoid solubilities of both primary and secondary alkylmercuric chlorides and their respective toxicities to Artemia (42). Many toxic materials are not avoided by fish. Studies were made on the effects of periodic low oxygen and it was found that when the D.O. was lowered to 2 p.p.m. for 2 hours in each 24 hr. period the materials under study become considerably more toxic: KCN about 4 times, Naphthenic acid, 2.5 to 3 times, and $ZnCl_2$ about 1/3 more (28). The accumulation of Zn^{65} in the clam, Meretrix meretrix, was high in the gill, mantle, viscera, and other soft tissue, but there was very little in the shell. About 40 percent of the radioactivity was lost in 2 days after removal to normal sea water. With the carp much of the radioactivity was deposited in the gills and kidneys as was the Zn^{65} injected into the muscles. After 48 hours, Sr^{90} injected into the muscles was found largely in the hard tissues; whereas Cs^{137} was chiefly retained in

the heart and kidney and found in both soft and hard tissues (165).

Phenol: Experiments with fractions of the black liquor from the sulphate process demonstrated that there was no relation between phenolic concentration and toxicity and that the most toxic fraction was the residue after distillation, which contained no phenols (21).

Ammonia: Bio-assay studies with un-ionized ammonia indicated that the period of survival for all species decreased as the concentration of the toxicant increased, decreasing D.O. increased toxicity with the greatest effects at the lower concentrations of un-ionized ammonia. Resistance of perch and roach to lack of D.O. was not significantly affected but that of rainbow trout was reduced significantly by a small concentration of the un-ionized ammonia (133).

Paper Mill Wastes: Sockeye fingerlings, *Oncorhunchus nerka*, were exposed to various concentrations of full bleach kraft effluent under experimental conditions simulating those anticipated in the estuary of the Somass River, British Columbia. At 17.8° C. in sea water of 20 percent salinity, the limiting concentration of toxicant below which survival was complete and independent of length of exposure, was 4.8 percent. However, when D.O. requirements for respiration and oxidization of the waste were considered, it was necessary to lower the concentration of the waste effluent from 4.8 to 2.5 percent (3). In studies carried on in Japan it was concluded that the harmful effect of paper mill wastes on aquatic organisms is mainly due to active Cl_2 in the effluent from the beater, in sediment of the bleaching liquor tank, and in the effluent from the

factory (95).

Detergents: In an investigation of detergents it was found that toxicity was mainly due to alkyl-aryl-sulphonate and that about 3 p.p.m. of this material produce a 50 percent fish mortality in about 12 weeks. When they are present more D.O. is required to sustain the fish. It is stated, however, that detergents do not constitute a threat to fishes (79).

Other Toxicants: Aquatic animals can tolerate concentrations of tannery wastes up to 4 percent when chromates are not present. The toxicity of tannery wastes is attributed to reduction in D.O., changes in salt concentration, and changes in acidity (209). Latex tubing used in a recirculating experimental apparatus in which the water was not exchanged proved toxic to stonefly nymphs. In jar tests the tubing caused the death of stoneflies in 72 hours and small Chinook salmon in 24 hours (46). A three year study of fish populations in White Oak Lake which received radioactive and chemical waste waters from Oak Ridge National Laboratory showed that fish in the lake grew more slowly and did not live as long as fish in nearby reservoirs of the T.V.A. Radioassay indicated that radioactive materials were selectively concentrated in all tissues of the body. Radioactive Sr and P were found in the hard tissues and Cs and the rare earths in the soft tissues. The total radiation received by the fish was estimated to be 57(rep)per year from external radiation and several times that amount from internal radiation (104). Fast swimming carnivorous fish fed Sr^{89} excreted most of it in a few hours. The remaining Sr^{89} was found mostly in the skeleton. Excretion was much slower and

retention much higher in a small sluggish herbivore. About three times as much Sr was found in the muscles of injected tuna as in those receiving the isotope orally while the gills had only half the activity found in orally fed tuna (19). When capsules containing 5.5 µc. of Y^{91} were placed in fishes stomachs it was found that the rate of loss of Y^{91} was very high, only 2 percent of the dose being retained after two days (20).

Insecticides:

The widespread use of the new organic insecticides and their increasing significance as water pollutants are indicated in the literature. The use of these materials for area control has resulted in several extensive fish kills and a reduction in the fish food organisms. The number and volume of aquatic insects emerging from tributaries of the Miramichi River of northern New Brunswick, where forest-covered watersheds had been sprayed from the air with 0.5 pounds of DDT per acre, were compared with insects emerging from unsprayed streams. It was found that there were fewer kinds of insects in the sprayed streams with the greatest reduction occurring in the larger species which are the main food of the young salmon (87). A sudden complete mortality of landlocked salmon fingerlings in a commercial fish hatchery was believed to be due to aerial spraying with DDT. Bio-assay studies showed that landlocked salmon are more sensitive to DDT than either rainbow or brook trout. Low D.O. levels increase the toxicity of DDT. Under conditions of oxygen saturation, 0.08 to 0.16 p.p.m., DDT is lethal to landlocked salmon but sub-lethal for rainbow and brook trout (73). Two applications of BHC, DDT,

and Strobane at the rate of 0.1, 0.2, and 0.3 pounds per acre respectively, were made to the tidal marshes of Bombay Hock National Wildlife Refuge. At this low rate of application no damage of consequence was observed from the two applications, with the exception of that to the marsh fiddler crab (64). Bio-assay tests with toxaphene indicate a three-fold increase in the toxicity to bluntnose minnows when the temperature is raised from 50° F. to 75° F. Toxaphene was found to be more toxic to the bluntnose minnow than to some of the aquatic invertebrates. In treated lakes many groups of invertebrates were killed but they reappered while the lake water was still toxic to fish. Detoxification in water proceeds more rapidly when it is exposed to light and where the temperature and D.O. were high (84). In July 1955, the U. S. Forest Service sprayed 132,856 acres of the upper Yellowstone River drainage with approximately 133,000 pounds of DDT for spruce budworm control. First observations of dead or dying fish in the area were made in mid October 1955. Mortality was extensive but predominantly whitefish were affected. Dead fish were in an emaciated condition and it is believed death was due to reduced food supply. Comparison of sprayed with unsprayed areas revealed a noticeable absence of stoneflies, caddis flies, and mayflies in the treated area (147). Bio-assays were made of the runoff water from an experimental plot before and after treatment with dieldrin. It was found that the runoff from the first rain from an area treated with dieldrin at the rate of 5 lb. per acre was toxic to fathead minnows in a one in three dilution. Some toxicity to fish was still present in runoff

from the third rain after treatment (186). The application of approximately 0.1 p.p.m. of toxaphene had a marked detrimental effect upon the Tendipedidae population of a northern Colorado lake. Living larvae were absent three days after treatment and repopulation was not complete until nine months later. The Oligochaetes exhibited no adverse effects from the toxaphene. Rotenone had little adverse effect when applied at 1 p.p.m. (43). A very good summary of the pesticides, their use and toxicity to wildlife, has been prepared by Rudd and Genelly (164).

Additional References

1. Anon. "Report of the Water Pollution Research Board with the Report of the Director of Water Pollution Research for the Year 1956." Dept. of Sci. and Ind. Res. HMSO, 80 (1957). "Effects of Pollution on Fish." Water Poll. Abs. (Brit.), 30, 137 (1957).
2. Berezina, N. A., "Damage to Fish from the Use of Insecticides to Control Biting Insects." Voprosy Ikhtiologii (Russian), 7, 209 (1956); Biol. Abs., 31, 2500 (1957).
3. Blumenkrantz, B. L., "The Effects of Chloretone on Developing Fish Embryos." Proc. Oklahoma Acad. Sci., 35, 62 (1954) (Pub. 1956); Chem. Abs., 51, 9952 (1957).
4. Fukuda, H., "Poisoning of Aquatic Animals with Some Toxic Substances - I. Method of Estimation of Toxicity." Bull. Jap. Soc. Sci. Fish., 21, 486 (1955); Biol. Abs., 31, 2194 (1957).

5. Jackson, C. F., "Control of the Common Sunfish or Pumpkinseed, Lepomis gibbosus, in New Hampshire." New Hampshire Fish and Game Dept. Tech. Cir. 12, 16 (1956); Sport Fishery Abs., 2, 2, 746 (1957).

6. Loosanoff, V. L., Hanks, J. E., and Ganaros, A. E., "Control of Certain Forms of Zooplankton in Mass Algal Cultures." Science, 125 (3257), 1092 (1957).

7. Lund, E. J., "Effect of Bleedwater, 'Soluble Fraction', and Crude Oil on the Oyster." Pub. Inst. of Marine Sci., 4, 328 (1957).

8. Parsons, J. D., "The Effects of Acid Strip Mine Pollution on the Ecology of a Central Missouri Stream." Dissertation Abs., 16, 1301 (1956); Sport Fishery Abs., 2, 6 (1956).

9. Phillips, A. M., et al., "The Nutrition of Trout." Fish. Res. Bull. 19, Cortland Hatchery Rept. 24, 1955 (1956).

10. Srinivasan, R., and Rajah, K. A. D., "Effect of Benzene Hexachloride on Fish Life." Indian Jour. Malariol., 9, 203 (1955); Chem. Abs., 51, 11598 (1957).

11. Starr, T. J., and Jones, M. E., "The Effect of Copper on the Growth of Bacteria Isolated from Marine Environments." Jour. Limn. and Ocean. 2, 33 (1957).

12. Taga, N., "Studies on the Effect of Copper Upon Marine Bacteria. I. The Depressing Activities of Copper Sulphate on the Development of Bacteria in Sea Water." Bull. Jap. Soc. Sci. Fish., 20, 280 (1954); Water Poll. Abs. (Brit.), 29, 338 (1956).

13. Tauson, A. O., "The Effect of Industrial Effluents on River-Bottom Fauna. II. The Effect of the Discharge of Effluents from Chemical Plants on the River-Bottom Fauna of the Kama and its Tributaries." Uchen. Zap. Molotov. Gosudarst Univ. im. A. M. Gor'kogo, (Russian) 7, 3, 71, (1955); Water Poll. Abs. (Brit.), 30, 288 (1957).

14. Timblin, L. O., Jr., Garstka, W. U., and Moran, W. T., "Preliminary Toxicity Studies with Hexadecanol -- Reservoir Evaporation Reduction." Chem. Eng. Lab. Rept. SI-10, U. S. Dept. of the Int., Bur. Rec., Div. Eng. Lab., Comm. Off., Denver, (1957).

15. Waugh, G. D., and Ansell, A., "The Effect on Oyster Spat Fall of Controlling Barnacle Settlement with DDT." Ann. Appl. Biol., 44, 619 (1956).

16. Weiss, C. M., and Botts, J. L., "The Response of Some Freshwater Fish to Isopropyl Methylphosphonofluoridate (Sarin) in Water." Jour. Limn. and Ocean. 2, 4, 363 (1957).

17. Wood, E. M., Yasutake, W. T., and Johnson, H. E., "Acute Sulfamethazine Toxicity in Young Salmon." Prog. Fish-Cult., 19, 64 (1957).

18. Yoshihara, T., and Abe, H., "The Toxicity of Chemicals on Fish I. Death of the Young Carp, Cyprinus carpio Linne, by Chemicals." Bull. Jap. Soc. Sci. Fish., 21, 950 (1955); Biol. Abs., 31, 2196 (1957).

19. Zimmermann, W., Lehmann, G., Schwille, F., and Schmeidler, E., "Effect on Water Supplies of Petroleum Products." Z. Hyg. InfektKr. (Germany) 142, 322 (1956); Water Poll. Abs. (Brit.), 29, 395 (1956).

Putrescible Wastes

Effects of Organic Enrichment

A Field study of two stream sections, one in its natural state and the other enriched by the sewage from a town of 500 people, showed that trout grew much faster, were in better condition, and the bottom fauna was more abundant in the enriched section (49). Physical, chemical, and biological surveys of the Sone River which receives wastes from kraft pulp mills, a sugar factory, and cement factory, show that the involved portion of the stream may be divided into five zones according to the degree of pollution. Toxic constituents of the pulp mill are well diluted even during the low flow period but the high organic content of the wastes reduce the D.O. to near zero and change water quality and bottom conditions for 15 miles, adversely affecting the fish and invertebrate habitat (138).

The production of oysters in the United States has declined to half its former volume. Domestic and industrial wastes affect the oyster bottoms by: direct poisoning of shellfish; smothering of shellfish grounds by sludge; and rendering the water unsuitable for harvesting shellfish because of the high bacteria content. Siltation has covered

covered many beds. Sulfite mill wastes encourage the diatom Melosira, which increases to the point where the oysters are smothered under a thick blanket of diatoms. Overfertilization by duck farm wastes produced a similar problem (58). In Britain many formerly productive oyster beds have either been abandoned or have declined in value as domestic and industrial pollution has increased (35). A study of the process of pollution and self-purification in oysters and mussels indicated that when the water temperature is above 10° C. both pollution and cleansing take place rapidly as the quality of the water overlying the bed alters and that both types of shellfish may become highly polluted. When the temperature of the water is about 1° to 2° C. mussels continue to show this same pattern of pollution and cleansing but oysters may not become polluted (210).

It is pointed out that suspended matter may represent a greater pollution danger than liquid effluents. The deposition of sludge on the stream bottom has many biological effects and is of outstanding importance (192). Fertilization can have very marked effects on plankton production and general productivity, transparency, and pH (142). Investigations of the area around three sewage outfalls in southern California indicated discoloration of the water and increased plankton growths (178). Investigation of a number of small ponds showed that the addition of sewage increased Daphnia populations (191). Experiments on eutrophication in mixtures of river water and effluents showed that algae titre is affected by numerous factors and can be used as a criterion of

the degree of eutrophication of water and mud (22).

Indicators of Organic Enrichment

The intestines of fishes caught off shore in the Mediterranean are free of entero-bacteria whereas in those caught in the littoral zone there is an intestinal flora similar to that in man or the warm blooded animals. Laboratory studies have shown that the investigation of the entero-bacteria and enterophages in fishes can give information as to the pollution of the waters in which the animals live (70). Bottom samples from Santa Monica Bay, California, indicate six biological zones, each supporting a characteristic fauna which differs with depth of sea floor, nature of sediments, and distance from the end of outfall sewers (72). Bottom fauna studies in the Los Angeles Harbor area in the vicinity of waste outfalls indicate that the area can be divided into five zones on the basis of bottom conditions and bottom organisms. Samples taken in a line away from the waste outfalls indicate that the number of species of bottom organisms increased with distance. *Capitella capitata* was found in the zone around outfalls and appears to occupy a position similar to *Tubifex* in fresh water (160). In the Los Angeles Bay area dredging provided new and clean bottom areas which were then colonized by benthic organisms. Within a year conditions deteriorated and oil sludges deposited on the bottom. The effects of the removal of contaminated bottom materials and the progress of contamination thereafter were demonstrated by D.O., sulfide, odor, organic carbon content of deposits, and the makeup of benthic populations (159).

Weimann believes that organisms serve as indicators of different degrees of organic enrichment or pollution and that the flora and fauna can give more information than chemical and bacteriological examination (202). From a bacteriological point of view the coliform group is currently considered the best available indicator for use in the estimation of pollution of waters and in the sanitary evaluation of pure waters of potable quality. Only when the count exceeds a normally expected minimum number of coliform organisms is pollution indicated (92). Fungi which are very common in association with decaying organic matter cannot be used as indicators of pollution because of their ubiquity throughout nature. Pollution tolerances occur but must be evaluated carefully in regard to individual species. A negative approach can be used wherein larger numbers of colonies of small numbers of species can be isolated from samples obtained in the more polluted portions of a single stream (38).

Results of river surveys have shown diatoms to be easy to collect and study and good indicators of river conditions. It is believed that similar relations hold for estuaries, bays, and ship canals as for fresh water rivers (151). From many studies that have been made it is believed that diatoms can be used as a group to indicate the ability of a water to support aquatic life. From variation in the number of species and individuals of each species, curves are developed which when compared may reveal waters adversely affected by pollution, mildly affected, severely affected, or not affected (150).

In Florida the indicator organism program is based on organisms which are indicative of the absence of organic pollution rather than on its presence (18). Number of species present and the abundance of individuals appear to be a criterion of pollution in lakes as well as in streams. In enriched areas the following forms were the most abundant: Tubificid worms, Procladius midges, Tendipes plumosus, and Tendipes tentans. Under conditions of severe pollution with organic wastes only the Tubificidae were able to survive (183). The genera of algae occurring most frequently in enriched waters are Oscillatoria, Euglena, Navicula, Chlorella, and Chlamydomonas. The five most abundant species are Nitzschia palea, Oscillatoria limosa, O. tenuis, and Arthrospira jenneri (148). Immediate sewage pollution of a stream, resulting in oxygen depletion, tends to eliminate all but a few species of anaerobic ciliates and colorless flagellates. Certain species of algae and protozoa are readily associated with sewage wastes but investigators should distinguish between "characteristic of" and "indicative of" organic enrichment (105). Certain mollusks, as the Unionidae, are not associated with near septic water resulting from organic enrichment. Such forms have an index value in that their presence typically indicates good D.O. and attendant physical and chemical conditions associated with clean water, and they may be called index organisms of clean water (89). Studies in the River Moravice indicated that several species of Trichoptera were indicative of pure water conditions. Among these are Polycentropus flavomaculatus, Notidobia ciliaris, Rhyacophila septentrionis, Glossosoma boltoni, and several

others (116). In order to utilize macro-invertebrates as indicators of environmental conditions in streams it is essential to have a knowldege of the composition of the population and the abundance of the different organisms under the various environmental conditions which prevail in clean and organically enriched waters. Clean waters are usually characterized by a great variety of invertebrates, consisting of herbivores, carnivores, and omnivores, lung, tracheal tube, and gill breathers. In general a population containing numerous gill breathing forms as mayflies, stoneflies, and caddis flies, is indicative of clean water and their absence denotes a superabundance of organic materials and/or low D.O. By contrast associations engaged in the utilization of excess organic materials are characterized by few species but large numbers of individuals. The macro-invertebrates most characteristic of septic zones are those which can exist under conditions of low oxygen or have adaptations for breathing atmospheric oxygen (63). The terms pollution and biological indicators are often loosely used. Biological indicators are generally indicators of organic enrichment. Pollution means damage to a beneficial use. Changes in an aquatic fauna do not necessarily mean there has been damage. It is believed that a more definite relationship must be shown between changes in the biota and damage to beneficial use before certain organisms can be referred to as pollution indicators. A study of the fish population and the fish catch gives the best information on how wastes are affecting sport or commercial fishing (47).

Additional References

1. Hohnl., W., "Biology of Waste-Water Fungi, with Special Reference to Pulp and Paper Mill Effluents." Wochbl. Papierfabrik, 84, 564 (1956); Chem. Abs., 51, 17163 (1957).

2. Mann, K. H., "A Study of the Oxygen Consumption of Five Species of Leech." Jour. Exp. Biol., 33, 615 (1956); Water Poll. Abs. (Brit.), 30, 13 (1957).

3. Muehlberger, C., "New Methods of Biological Investigation of Ground Water." Wasserw.-WassTechn., 6, 45 (1956); Water Poll. Abs. (Brit.), 30, 49 (1957).

4. Skerman, V. B. D., Dementjeva, G., and Carey, B. J., "Intracellular Deposition of Sulphur by Sphaerotilus natans." Jour. Bact., 73, 504 (1957).

MICROBIOLOGY

An explosive epidemic (195) of infections hepatitis in Delhi, India was attributed to municipal drinking water, and showed that the virus was not inactivated by the treatment methods used. This incident indicated that contamination of the drinking water supplies by sewage should be avoided, if at all possible.

Richter (162) has reported the presence of at least 8 species of Salmonella present at various times in channel water in Buxtehude Rasch, Germany. He noted the increasing occurrence of the Salmonella group in western Europe as a result of intercontinental travel. Stoll (179) reviewed the legal provisions of the German Democratic Republic in an attempt to prevent human infection through polluted waters from slaughter houses. The conditions under which Salmonella can live and grow in water, such as presence of protein materials, effect of salinity, influence of movement and stagnation were discussed by Steiniger (177). He concluded that the degree of pollution, oxygen demand, and coli content are not suitable methods of determining the presence of infectious agents; more Salmonella may be present in apparently clean water than in a polluted water. Greenberg, Wickenden and Lee (69) have successfully identified an S. typhi carrier in a town of 2200 by application of the swab procedure developed by Moore, in which gauze swabs were suspended in sewage at various points through the sewer system and followed back through house connections into the toilets. A new procedure for the more rapid isolation

of Salmonella from polluted water was described by Kenner, Rockwood and Kabler (99). The technique combined the use of a selective medium, selenite brilliant green, with membrane filter culture.

Gol'dfarb (67) demonstrated dysentery bacilli in low concentration in water by the phage titre increase reaction. In experimentally infected well water, bacteria were detected in lower concentration and over longer periods of time than in tap or river water. Kenner and Kabler (98) isolated five strains of Mimeae from Ohio River water. All previous isolations of these organisms have been made directly from specimens of human origin. Greenberg and Kupka (68) have reviewed "Tuberculosis Transmission by Waste Water". Hospitals treating tuberculosis patients, as well as dairies and slaughter houses handling tuberculous animals may be expected to discharge tubercle bacilli in their wastes. Conventional sewage treatment is inadequate to significantly reduce the number of tubercle bacilli in the sewage. In order to provide adequate disinfection, complete treatment plus chlorination with 20 p.p.m. for at least 2 hours contact time is necessary. Cooke and Kabler (40) and Cooke and Busch (39) found sewage polluted waters to be rich in certain strains of "plant disease fungi" and cellulose-decomposing fungi which have become acclimated to living in aqueous habitats, and which were able to use dissolved oxygen in competition with other sewage organisms for reduction of organic materials. During the treatment of sewage and wastes these fungi were active in purifying sewage in which they were living.

Dauer and Sylvester (44) in their "1956 Summary of Disease Outbreaks"

included nine water-borne outbreaks in which 1,719 persons were affected. Two large and two small outbreaks were from contaminated public water supplies, one of 800 cases was due to Shigella flexneri. One outbreak of typhoid fever, 27 cases, was attributed to contaminated well water. One outbreak of infectious hepatitis of 276 cases was considered water-borne and E. coli was isolated from the supply.

Hendriksen (78) has extended his studies on coliform tests of water carried out in mannitol broth at 30°C. followed by subcultures in lactose broth at 39°C. The rate of coliform detection was higher by the new method and seemed to give more reliable results than tests in lactose broth at 37°C. Karakasevic (94) made a comparative study of culture media for the enumeration of coliform bacteria, and recommended that the technique now in use in Yugoslavia be replaced by "Standard Methods" (U.S.). In his study of the effect of storage temperature on the survival of coliform organisms in water, McCarthy (127) found that water samples with relatively low coliform densities (23 or less) which had been in shipment up to 24 hours at any reasonable temperature yielded results which statistically correlated very well with the degree of pollution existing at the sampling point at the time of collection. Samples with higher initial coliform densities, 230 or more, were more likely to exhibit decreases in coliform content during 24 hours storage. Njoku-Obi and Skinner (144) consistently obtained lower counts of coliforms and Escherichia species in boric acid lactose broth at 43°C. than when standard lactose broth was used at 35°C. They concluded that boric acid lactose broth cannot be depended upon to

detect fecal coliforms, although they did not clearly define their criteria for differentiating Escherichia, Aerobacter and intermediate forms.

Sullivan, Bartley and Slanetz (182) reported that the enterococci occur in the feces of man and certain animals and in polluted water or sewage in as great or even greater numbers than do the coliform bacteria, and that in some instances it may be possible to distinguish between human and animal contamination of water based on the types of enterococci present in the samples. In the examination of 1000 water samples in Argentina, Leiguarda et al (113) demonstrated contamination in 332, 83.1% contained coliforms and 45.8% contained streptococci. Because 16.9% of the contaminated samples contained streptococci only, they considered the possibility of adding tests for streptococci to the other methods used in the bacteriological examination of water.

Reitler and Seligmann (161) showed that Pseudomonas aeruginosa and E. coli can coexist in pure water, but in mixed cultures, in peptone water Ps. aeruginosa can inhibit E. coli. Water supplies containing many Ps. aeruginosa but few or no coli-aerogenes bacteria were found to be relatively common in northern Israel and in view of Ps. aeruginosa's fecal origin and its potential pathogenicity, it was concluded that this organism should be considered as well as the coli-aerogenes bacteria in assessing the suitability of water for drinking purposes. Due to the high concentration of cytochrome oxidase within the cells of Ps. aeruginosa a practical differential test has been developed (57) based on the formation

of indophenol blue from the oxidation of P-aminodimethylaniline oxalate in the presence of alpha naphthol. This test suggests the possibility of a procedure for the selective enumeration of Pseudomonas in polluted water.

Collin and Kipling (36) have devised a new technique for the enumeration of water-borne bacteria by a "direct count method". Results by the direct count were from six times to 11,000 times greater than by the colony count. Fournelle (54) described a procedure for determining the potability of water supplies in the field, which is said to be adaptable to special areas for removal from a laboratory. Fournelle and Page (55) found the dye uranin and Streptococcus zymogenes to be satisfactory indicator agents to determine the direction and rate of travel through ground waters. Robson (163) added Serratia indica to sewage to determine the distribution of effluent material discharged into the sea.

Willis (206) showed that black colonies 3 mm. or more in diameter, which developed on Wilson and Blair's medium inoculated with untreated water from a city's supply, signified the presence of Clostridia, usually Cl. welchii. He (205) also found anaerobic bacilli in the sand from the filter-beds of a city water supply, and thought it probable that these organisms were being added to the water as it passed through because anaerobes were present in the treated water. It was pointed out that the anaerobe test on treated waters was useful in assessing filter efficiency.

Friberg and Hammarstrom (56) studied "the effect of free available chlorine on bacteria and bacterial viruses". At pH 7.2 and temperature

of 6° C., exposure for 1 minute to a concentration of 0.025 to 0.05 mg/L chlorine effected a thousandfold reduction of typhoid bacilli, S. sonnei and coliform bacteria, but concentrations of 0.10 to 0.15 mg/L chlorine were necessary to effect the same reduction in numbers of Sal. typhimurium, Strep. faecalis and Staph. aureus. The coliform, sonnei and typhimurium phages were reduced a thousandfold by concentrations of 0.04 to 0.07 mg/L free chlorine. Kelly and Sanderson (97) pointed out that chlorine residuals found to be sufficient for bacterial disinfection were not similarly effective as viral disinfectants, and that inactivation of Poliovirus by chlorine may follow a course not strictly linear. Watkins, Hays and Elliker (201) made a comparison under laboratory conditions of the relative effectiveness of representative hypochlorite, quaternary and iodophor germicides in the destruction of Strep. cremoris phage. The results suggested that an active hypochlorite preparation should provide the most effective sanitizing procedure for control of bacteriophage in dairy plants. Fetner and Ingols (52) determined the lethal concentration of ozone for E. coli suspensions at 1° C. to be 0.4 to 0.5 mg/L. Ladendorf and Ladendorf (106) have made similar observations on the efficiency of chlorine dioxide for disinfecting water.

Lowe and Lindsten (120) have summarized the removal of CBR contaminants from water. Lewisite and nitrogen mustard can be effectively removed by treatment with activated carbon followed by good coagulation and filtration; GA and GB were reduced by treatment with soda ash plus coagulation and filtration. Sal. typhi, Coxiella burnette and Botulinum toxin

were removed by coagulation, filtration and chlorination to 20 minute residuals of 0.35 to 0.75 p.p.m.

Taylor in England (188), Schiavone and Passerini in Argentina (168), Adams in Pennsylvania (1), and Gohar and Eissa in Germany (66) have compared the membrane filter technique with other acceptable methods in the bacteriological examination of water. They have pointed out certain advantages of the method and have also listed limitations. These advantages and limitations have been discussed by Clark, Kabler and Geldreich (32). Felsenfeld and Rokkaku (51) have adapted the membrane filter technique to the recovery of Vibrio comma from water supplies and Papavassilion and Wegner (149) have used the technique for the detection of sulfite-reducing Clostridia (Cl. perfringens) in water and other liquids.

Levin, Harrison and Hess (115) have published further observations on the use of radioactive culture media in the enumeration of coliform organisms in water. pH exerts a pronounced biological and chemical effect on the test. When the broth is alkaline, much of the carbon dioxide remains in solution in the form of the bicarbonate ion. The nonmetabolic evolution of $C^{14}O_2$ from the sterile 1-C^{14} lactose is the chief immediate problem demanding attention in the development of the test.

Additional References

1. Cooke, W. B., "Nutritional Requirements of Nine Common Sewage Fungi." THIS JOURNAL, 29, 11, 1243 (Nov. 1957).

2. Hurwitz, C., Rosano, C. L., and Blattberg, B., "A Test of the Validity of Reactivation of Bacteria." Jour. Bact., 73, 743 (1957).

3. Johannesson, J. K. and Martin, R. E., "The Determination of Escherichia coli I in Sea Water." Jour. Appl. Bact. 20, 151 (1957).

4. Jones, G. E., "A Study of the Pectolytic Bacterial Population in Some Farm Water Supplies." Jour. Appl. Bact. 19, 231 (1956).

5. Kelly, S., Winsser, J., and Winkelstein, W., Jr., "Poliomyelitis and Other Enteric Viruses in Sewage." Amer. Jour. Pub. Health, 47, 72 (1957).

6. Rogovskaya, T. I., "Influence of Aminocarboxylic Acid Lactams on Microorganisms in Water and Biochemical Processes in Self-purification of Water." Microbiology (USSR), 23, 464 (1955); Jour. Amer. Water Wks. Assn., 49, 2, 66 (1957).

7. Slanetz, L. W. and Bartley, C. H., "Numbers of Enterococci in Water, Sewage, and Feces Determined by the Membrane Filter Technique with an Improved Medium." Jour. Bact. 74, 5, 591, (1957).

8. Stack, V. T. Jr., "Toxicity of Alpha, Beta-Unsaturated Carbonyl Compounds to Microorganisms." Ind. Eng. Chem. 49, 913 (1957).

9. Woodward, R. L., "How Probable Is the Most Probable Number?" Jour. Amer. Water Wks. Assn., 49, 1068 (1957).

CHEMISTRY

Heukelekian (80) assembled a notable symposium in which it was sought to present a review of the basic microbiological processes related to purification of polluted waters. While many of the papers may be noted elsewhere, the assembled symposium is deserving of attention. It includes discussions by Wyss on "Microbial Adaptation"; Weindling on "Microbial Associations and Antagonisms"; Nickerson on "Transformations of Carbon Compounds"; Delwicke on "Biological Transformations of Nitrogen Compounds"; Starkey on "Transformations of Sulfur by Microorganisms"; Barker on "Biological Formations of Methane"; Davis on "Microbial Decomposition of Hydrocarbons"; and Krauss on "Photosynthesis in the Algae". Each article is discussed by one or more authorities.

The direct chemical characterization of organic water pollutants has found continued application and study. Middleton and Rosen (135) review technique and discuss trends in organic industrial pollution which make specific chemical characterization of pollution a matter of growing importance. Holluta and coworkers (82)(83) have also presented the details of techniques generally aimed at the recovery and characterization of organic materials in surface water and water taken from infiltration galleries.

In a paper which was overlooked in the 1956 review, Sawyer (166) and his students reported on the interrelationship of rates of biological assimilation and chemical structure of synthetic detergent materials. An additional report considering the effect of commercial synthetic detergent ingredients on water and waste quality was presented by Sawyer

and Ryckman (167).

Hexadecanol (Cetyl Alcohol) has been investigated as a water pollutant because of interest in the material as a possible suppressor of evaporation. Laycock (107) commented on the effect of the material on aquatic life. Ludzack and Ettinger (121) report laboratory studies of the biological destruction of hexadecanol and point out that the material undergoes biological destruction under laboratory conditions which simulate proposed use conditions.

Other studies of the biological stability of various materials appeared. Hatfield (74) studied the biological stability of 23 compounds produced by petrochemical processes, using activated sludge cultures acclimated to the chemical for periods of a month. Ludzack and Kinkead (123) made laboratory studies of the oxidation of hydrocarbons derived from motor oil by microorganisms. They also presented analytical evidence of the formation of intermediate oxidation products.

Mills and Stack (136) emphasized the importance of using acclimated seeds when attempting to estimate the B.O.D. load caused by an industrial waste.

In an interesting application, Christenson, et al., (31) proposed the use of activated sludge using nitrate ion as an oxidant source, methyl alcohol as organic feed, in a system where removal of nitrate from a waste was sought.

Additional References

1. Christ, W., "Phenols in Potable Water and Their Significance." Freiberger Forschungshefte (Germany) 67 (1956); Literaturberichte (Germany) 5, 772 (1956); Pub. Health Eng. Abs. 37, 12, 25 (1957).

2. Davis, J. B., "Microbial Decomposition of Hydrocarbons." Ind. Eng. Chem., 48, 1444 (1956).

3. Hoak, R. D., "The Causes of Tastes and Odors in Drinking Water." Water and Sewage Wks., 104, 6, 243 (1957).

4. Keilling, J., "The Contamination of Soil and Waters by Products Used in Agriculture." Eau (France) 43, 277 (1956).

5. Starkey, R. L., "Transformations of Sulfur By Microorganisms." Ind. Eng. Chem. 48, 1429 (1956).

OXYGEN SAG AND STREAM SELF-PURIFICATION

In the third of a series of reports on comprehensive studies of the character and stream self-purification characteristics of Wisconsin rivers, Lueck et al (124) have presented analysis by several devices of the stream self-purification capacities of the Fox and other Wisconsin rivers. They have suggested that the self-purification capacity of streams may be compared on the basis of pounds per day of ultimate BOD satisfied per 1,000 cfs per mile, or on the basis of the time required to oxidize 90% of the ultimate BOD taken together with the deoxygenation velocity constant k_1, or on the basis of pounds per day of 5-day BOD per cfs per part per million of D.O. removed. The capacity of the Lower Fox River at various seasons and in several reaches is compared on the above bases. This report represents a considerable amount of work, and some most interesting data is presented.

On the basis of the third of the above noted units for comparison, namely, pounds of 5-day BOD per day per cfs per part per million of D.O. removed, the authors conclude that "at low temperatures, when the stream purification proceeds at a slower rate, considerably higher loadings can be supplied to the stream without adversely affecting downstream conditions." And at a later point "it is evident from previous discussion that the lower the purification rate, or k_1 factor, the greater may be the load applied to the stream. Any factor such as limited biological activity at lower temperatures or characteristics of the waste to be

oxidized which tend to decrease purification rate, will improve purification capacity and make possible the satisfaction of higher loadings."

This concept is rather unusual in that it might imply, for example, that unlimited loads could be placed upon a stream in the event k_1 were reduced to zero - by the presence of sufficient amounts of toxic materials, for example. The 5-day BOD is, of course, affected by the course of reaction, or k_1, while the ultimate BOD, at least in principle, should not be thus affected. It is therefore difficult to understand why the authors chose to use the 5-day BOD in this case for the purpose of interpreting self-purification capacity in terms of k_1. It would be interesting to compare the stated stream self-purification capacities on the basis of ultimate rather than 5-day BODs. Conceptually, if the entire river is considered rather than a restricted reach, the entire pollution load introduced at any point must eventually be satisfied, and the critical point of the oxygen sag curve may or may not occur within this restricted reach, depending upon the specific circumstances involved. It is agreed that somewhat higher loadings may be tolerated at lower temperatures, but the primary reason for this is the increase in oxygen saturation values, rather than the reduction of k_1.

The above paper also presents very interesting implications of the effects on self-purification capacity of large concentrations of algae.

Mills and Stack (136) have presented an interesting discussion of the effects of acclimation of seed on the course of the BOD reaction in

the case of four pure petrochemicals. The 5-day BODs of the petrochemicals are compared using both unacclimated and acclimated seeds. The organic chemicals used were acrylonitrile, ethylene glycol, carbitol, and acetone. Only the acetone yielded classical BOD behavior without acclimation of the seed. In the other cases, the use of acclimated seed resulted in higher BOD values, more closely approximating the oxygen demands actually exerted in a stream. The authors suggest that, to evaluate the effects of other organic chemicals on stream self-purification capacity, the ultimate BOD should be determined by the use of acclimated seed organisms.

That the potential pollutional effects of organic materials are a function not only of their BOD as usually measured, but also of their persistence and relatively slow oxidation, has been indicated by Ettinger (50). It is indicated in this paper that the theoretical oxygen demand may be distributed at any time as: material oxidized to carbon dioxide, unoxidized readily available food, cell material, and unoxidized exotic food. The actual distribution among these four phases will, of course, be dependent upon the characteristics of the material involved. Selected examples are taken from the literature to demonstrate the effect of acclimation of seeds on organic materials previously looked upon as essentially unoxidizable.

Nickerson (143) has presented metabolic maps of various hydrocarbons, oxygenated compounds, and amino acids as a basis for the understanding of sewage treatment and stream self-purification mechanisms.

Leclerc et al (108) have provided an example of the determination of self-purification capacity of a river for the purpose of obtaining water of sufficient purity for the food industry. Pillai et al (153) present an intensive reivew of the literature on the subject of stream self-purification capacity, together with information regarding self-purification of untreated sewage from Bangalore, India, in a series of open channels. Muller (139) also presents a general review of the factors involved in stream self-purification, notes the inadequacy of even complete biological treatment in densely populated regions, and discusses possible methods of increasing the stream self-purification capacity.

Rand (156) has presented an excellent critical review of the available literature on theoretical aspects of the reaeration factor. In doing so, he has traced the development of theoretical concepts on this subject from their beginnings through the most recent work, including that of O'Connor and Dobbins (146). The article provides an excellent review of the available material and correlates the various concepts involved. It is recognized that the work of O'Connor and Dobbins makes possible for the first time predictions of k_2 independent of observed data. Rand indicates that the effects of turbulence on the reaeration velocity constant are only now beginning to be understood, and that much further work remains on this phase of the problem. The evidence that he has accumulated indicates that the effects of temperature on the reaeration constant are adequately known, but that the effects of various pollutants including ordinary sewage, as well as detergents, insofar as such

pollutants affect reaeration, are not well known as yet. In another discussion on this subject Rand (157) presents the results of some of his own experiments on reaeration. Upon examination of various factors which might affect the reaeration rate, he indicates that the BOD correlates best with the observed reaeration rates. Both quiescent and agitated systems were investigated with the same relative effects observed.

Gameson (60) has presented the results of a study of reaeration occurring as the result of water passing over weirs in rivers. He reports that the oxygen content of the water may be increased as much as 50 percent of saturation, and an empirical equation to represent these effects is presented. The effects of various types of weirs are discussed. Wagner (197) describes the use of turbines of water power works for the purpose of oxygenating canalized streams. He discusses experiments carried out on the River Brenz, the air requirements, and the effects of various design features of the turbines.

The subject of estuarine pollution is receiving considerably more attention in the recent literature. Kaplovsky (93) has described his investigations of pollution of the Delaware River, using the "same-slack" sampling technique, and his results are most interesting. The "same-slack" method consists of taking from one to three surface water samples in the ship channel at each sampling station just at the time that the tide begins to turn. In other terms, a sampling run is made in which the samples are collected at all stations at the slack of the same tide. That such surface samples are representative of the ship channel water

is demonstrated. Kaplovsky concluded that this method of sampling provided results more valid than those obtained by cross-sectional sampling. His data indicate that the "same-slack" method eliminates much of the effect of tidal periods and the results are therefore more easily interpretable. He also indicates that his studies of the Lower Delaware River indicate no appreciable deviation from the usual picture of self-purification of inland streams, and the data regarding the nitrogen balance is especially interesting in this regard.

Burt and Marriage (27) have presented a theoretical analysis of the distribution of pollution in the Yaquina River in Oregon on the basis of Stommel's (180) equations. The study involved wastes from a proposed pulp mill on the Yaquina River, and five possible outfall locations were investigated analytically. The computations indicated that the pollution concentration near any outfall, as well as the concentration upstream from the outfall, would decrease rapidly as the outfall was moved toward the ocean. However, concentrations at any given point downstream from two or more outfalls were found to be esentially independent of the position of the outfalls. Following these analytical studies, it was decided to pump the pulp mill waste directly to the ocean and to thereby avoid significant pollution of the Yaquina River.

An analysis of factors affecting the oxygen balance in the River Thames Estuary has been presented by Gameson and Preddy (59). The data include dissolved oxygen observations in the estuary over a period of several years. The various sources of pollution have been

considered and a theory of mixing outlined on the basis of which the distribution of oxidizable material from different groupings of waste discharges has been computed. The oxygen balance of the entire estuary was then examined and an average rate of solution of oxygen from the atmosphere estimated. The oxygen balance having been thus estimated, the theory has been checked against a variety of observed conditions in the estuary and agreement of observed and computed data obtained. On this basis, it was then possible to predict oxygen changes most likely to occur as the result of various alterations of pollution loads and other controlling factors.

Ingram (90) has presented a general review of the factors which affect estuarial capacity for receiving wastes. The factors considered include tidal displacement, fresh water flow, tidal flow, wave action, density currents, vertical and horizontal countercurrents, stratification, and diurnal and nonperiodic wind effects. Combinations and complications of these factors are also discussed. Mann (130) has also presented a discussion of the general hydrologic conditions in a tidal river and illustrated the principles involved by the example of behavior of sewage from the City of Hamburg discharged into the River Elbe. The self-purification capacity of the tidal stream and effects of polluted tributaries are discussed.

Additional References

1. Downing, A. L., and Melbourne, K. V., "The Effect of a Foam-suppressor on the Aeration of Polluted Water." Water and San. Engr. (Brit.), 6, 148 (1956).

2. Grindley, J., and Wheatland, A. B., "Salinity and the Biochemical Oxygen Demand of Estuary Water." Water and San. Engr. (Brit.), 1, 10 (1956).

3. Hagiwara, K., "Studies on the B.O.D. Velocity Constants and Immediate Oxygen Demand." Bull. Inst. Pub. Health (Japan), 5, 4, (1956).

4. Krauss, R. W., "Photosynthesis in the Algae." Ind. Eng. Chem. 48, 1449 (1956).

5. Lardieri, N. J., "Aerobic and Benthol Oxygen Demands of Cellulosic Materials." Proc. 11th Ind. Waste Conf., Purdue Univ., Series 91, 1, (1957).

6. Niles, T. M., "Dispersal of Pollution by Tidal Movements." Jour. San. Eng. Div., Proc. Amer. Soc. Civil Engrs., 83, 1408 (1957).

7. Simmons, J. D., Nemerow, N. L., and Armstrong, T. F., "Modified River Sampling for Computing Dissolved Oxygen Sag." THIS JOURNAL, 29, 8, 936 (Aug., 1957).

8. Truesdale, G. A., and Knowles, G., "Some Recent Work on Dissolved Oxygen in Natural Waters." Extrait Du Journal Du Conseil International Pour L'Exploration De La Mer (France) 21, 3, (1956).

9. Truesdale, G. A., and Gameson, A. L. H., "The Solubility of Oxygen in Saline Water." Extrait Du Journal Du Conseil International Pour L'Exploration De La Mer (France) 22, 2, (1957).

STREAM STUDIES AND SURVEYS

Water resource development and conservation with associated water pollution control continues to be of prime importance. Many stream studies, however, fail to reach formal publication and therefore are not reviewed. A greater effort should be made to encourage publication. It may be noted this year that several studies of European waters have been reported.

Tsivoglou, Harwood and Ingram (189) emphasize the importance of stream surveys for adequate control of radioactive liquid waste discharges associated with the rapidly developing private use of radioactive materials. Excessive radioactive wastes from nuclear reactors, uranium mills, and radioisotope research laboratories will interfere with other legitimate stream uses. There is no stream self-purification capacity for radioactive wastes as there is for ordinary organic pollutants. Control is based on three types of stream samples - water, aquatic biota, and bottom deposits.

A survey was reported by Schneller (171) of a 25-mile stretch of Salt Creek, Indiana, to examine the physical and chemical characteristics of the water during the black-water period which persists during leaf-fall, and to compare this condition with that during the remainder of the year. The dissolved oxygen content was shown to decline to a minimum of 0.5 ppm during the leaf-fall when free carbon dioxide was as high as 20 ppm; during the remainder of the year the dissolved oxygen and free carbon dioxide ranged from 5-12 ppm and 5-15 ppm respectively. The effect of extreme conditions on fish life is discussed, no serious fish mortalities

normally occur. Wiley, et al (204) describe the combined chemical, physical and biological studies on the Lower Fox River, Wisconsin, during 1955-56 through the cooperative efforts of State and industry to determine sources of pollution and the self-purification capacity of the stream. Combined artificial and natural pollutants cause critical dissolved oxygen conditions below major sources of wastes especially during hot weather. Detail study of algae problems will be required to assess more accurately the amount of organic matter derived from this source since it appeared that algae contributes a substantial portion of organic load during warm weather. Scott, et al (173) discuss the organization of cooperative State-industry studies in Wisconsin. The cooperative approach permits assembly of much more complete data covering more of the variable factors than would otherwise be available to either industry or government acting alone. Chemical, physical and biological characteristics of a 30-mile stretch of the Ottawa River below an oil refinery near Lima, Ohio was presented by Ludzack, Ingram and Ettinger (122). Evidence indicates that oil was not biologically assimilated but stored as oily sludge on the river bottom and flushed by periodic river rises. Accumulated sludges, as these, are believed to be responsible for extreme impairment of water quality which sometimes occur when a river is flushed out following a long period of low flow.

The effects of polluted waters of the Flon on Lake Geneva at Vidy were studied by Monod (137). It was concluded that the chemical composition

of the lake water was not altered by the Flon but that turbidity and the quantity of micro-organisms were increased greatly. Noisette (145) conducted surveys on a continuing basis of the mineral content of the rivers in France. The source of minerals was geological, urban and rural sewage, and industrial wastes. The conclusions were that the sources of salts are constant, variation in mineral content of the rivers depending on rainfall and flow. The degree of variation requires precaution by industrial users; geologic factors acting alone can cause high mineralization.

Leclerc, Beaujean and Heuse (110) studied the pollution and self-purification of the Geer River. They indicate that the principle observations guiding such a study should be based on temperature, time and turbulence. Particular attention should be paid to gradient, flow and temperature. Leclerc and Beeckmans (109) describe a series of studies on the Sambre River. Data were gathered on flow, temperature, pH, settleable and suspended solids, dissolved oxygen, 5-day B.O.D., sulfates, iron, chlorine and toxicity. The stream was found to be very polluted. LeStrat (114) observes that difficulties in sewage treatment attributed in the United States to detergents have not been experienced in France because, except in a few large cities, laundry water is dispersed to the ground via gutters. As a check on detergents, surface tension determinations are made constantly on the Seine, Marne and Oise rivers and on the Chicky interceptor sewer. While the value for pure water is 74-75 dynes, the rivers run to 70 dynes and the sewer is below 65, sometimes down to

58 dynes.

An article based on the work of Kalweit and Brandt (10) indicates that hardly a river in Central Germany reaches a scale of water quality satisfactory for bathing purposes; ground water is being utilized to a greater extent by industry and municipalities due to this condition. Further it is shown that damage to fisheries on the streams of the German Republic can be caused by removal of oxygen, sewage fungus, presence of metal salts from mining and metal industries, sand, clay, kaolin, coal dust, and cyanide and phenol from chemical industries. Fijiwara et al (53) state that the river Yukawa, Japan, contains sulfuric acid derived from sulphur deposits in the Yatsugatake volcanoes districts. The acid is considerably neutralized when the Yuhawa River joins the Chihuma which is used for irrigation and fishing. If the sulphur deposits are mined, it is believed that the increased concentration of acid will damage the use of water.

A summary (7) of a paper by Harwood and Wilson presents an investigation, including a model study, which considered disposal of up to 500,000 tons per year of power station ash by cooling water conveyance for disposal by sea; barging to sea was the alternate. Eighty percent of the ash would be borne away to sea in the cooling water stream and in calm weather be deposited beyond the outfall. When waves are 2 ft. and upwards, this deposit would be broken up and moved out to sea. Experiments in the wave channel pointed to the material being distributed at depths as great as 40 fathoms and probably more, with likely dispersal over a wide

area of the North Sea. Shapiro (174) reported on pollution survey sampling of N. Y. Harbor. The first problem dealt with the extent New York Harbor and adjacent waters were actually polluted and the second problem was concerned with the tidal and current distribution of the polluting load. Extensive pollutional and hydraulic surveys were necessary to ascertain details of the problem and background for corrective measures.

The good and bad features resulting downstream from water storage for hydraulic power generation is discussed by Ingols (88). On the good side, water below a dam contains less sediment, color, bacteria, and has a lower temperature. The bad features, oftentimes not fully appreciated, are that directly below the dam, water may be devoid of oxygen during the summer when water quality is critical, and may contain manganese or sulphide. Furthermore, flow pattern of power generation may permit slime development on the bottom during low flow and scouring off of slime during high flow; wastes may be stored in tributaries during high river stages and discharged to the river during falling river stages, and, a city may discharge its heaviest sewage load during minimum river stage if located 12 or 36 hour flow time downstream from the dam.

STREAM STANDARDS

Vinogradov (194) reports that the Sanitary Authority of the U.S.S.R. regulates the concentrations of certain substances in waste waters discharged to streams. These include:

Substance	Concentration, mg per liter
Lead, copper, nickel, cyanide, chromium	0.1
Picric acid, di- and tri-nitrotoluol, dinitrochlorobenzole, tetranitromethane	0.5
Mercury	0.005
Arsenic	0.05
Fluorine	1.5
Carbon disulfide, dinitronaphthalin	1.0
Carbon tetrachloride	5.0
Dichloroethane	2.0
DDT	0.2
Chlorine	0.0

In Austria Liepolt (118) concludes that the primary importance of hygienic considerations justifies the general aim of restoring all Austrian surface waters to their natural condition. He suggests that the minimum standard should be the maintenance of beta mesosaprobic conditions at all times. This biological classification, proposed by Kolkwitz and Marsson, describes the zone of stream recovery, following severe pollution, in which mineralization is approached, blue-green algae, diatoms and varied

animal forms occur, and dissolved oxygen nears saturation.

The Ohio River Valley Water Sanitation Commission staff (6) has proposed a plan for controlling chloride pollution of the river. The average monthly chloride concentration on the main river should not exceed 125 ppm, based on the most probable minimum monthly-average 10 year flow, and the maximum concentration should never exceed 250 ppm. The commission's primary concern in selecting chloride limits was prevention of corrosion of metal structures rather than protection of health. The low limit needed to prevent corrosion assures chloride concentrations below those acceptable in public water supplies. Alternate schemes for computing allowable discharges of chloride wastes from individual sources are described.

EFFECTS ON WATER SUPPLIES

Kazuaki (96) attributes an outbreak of acute intestinal disease to contamination of a water supply by wastes from a sweet potato starch factory.

Zimmerman (211) reports on an incident of contamination of the Trier (Germany) water supply due to explosion of a kerosene tank which released kerosene to a tributary of the Moselle above the town. He also discusses the problems of both surface and undergound pollution by motor fuels and precautions in choosing sites for and constructing storage tanks for such fuels. The California State Water Pollution Control Board (11) has published a report on an extensive literature survey on the effects of oily substances on beneficial uses of water. Garrett (62) discusses the problem of possible toxic effects of various chemical pollutants in industrial wastes.

A report on the continuing struggle to protect the London (England) water supply against pollution was made (9). The problem of protecting water supplies against radioactive contamination resulting from nuclear reactor operations was discussed at the Nuclear Congress (13).

ABATEMENT AND CONTROL

The completion of the last link in the $80 million sewage collection and treatment system in Philadelphia is reported on by Baxter (16). Some 66 miles of collecting and intercepting sewers plus three sewage treatment plants have been financed by sewer service charges since 1946. Plans are underway between Philadelphia and neighboring communities to bring sewage from outlying areas to the Philadelphia plants. When these arrangements are completed practically all raw sewage will have been eliminated from the Schuykill and Delaware Rivers in the Philadelphia area.

Spies (176) reports on the progress in the stream pollution control in Oregon. Since the initiation of the State program in 1938 an estimated $50 million have been expended by municipalities, industries, and others for pollution abatement. During this period the State's population has increased more than 50 percent, however, the population equivalent of municipal sewage discharged without treatment has decreased from 450,000 in 1938 to 60,000 in 1956. In 1938 less than 1 percent of the industrial wastes was being treated while in 1956 over 78 percent received treatment, despite a 67 percent increase in population equivalent of industrial wastes during this period. Much additional work is required, however, to protect Oregon's waters. It is estimated that 100 communities require new or improved facilities which will cost at least as much as has been spent since the inauguration of the program, and several existing industries

will likewise require new or improved treatment facilities.

Cleary (33) in reviewing the progress being made to clean up the Ohio River points out that when the Ohio River Valley Water Sanitation Commission was established in 1948 less than one percent of the population on the Ohio River provided treatment. In 1957 facilities are in operation or under construction to serve 86 percent of the population. Good progress is also being made by the industries as evidenced by the fact that more than two-thirds of those plants discharging effluents into the streams of the Valley now comply with Commission minimum requirements for pollution control. Much more work remains to be done, however.

McCallum (126) reports on the first year of operation of the Construction Grants program under Public Law 660. This section of the Federal Water Pollution Control Act authorizing construction grants has been the subject of much controversy as to whether or not it would stimulate or retard sewage treatment works construction. Because of the time required for setting up procedures for administrative grants program no grants could be offered until December of 1956. Reports from state water pollution control agencies as well as Contract Awards data indicate that the construction picture looks encouraging despite the advent of factors tending to retard construction, the principal one of which is the "tight" money market.

The Engineering News-Record (112) in evaluating the first year's operation of the Construction Grant Program cites data indicating that Federal Grants have stimulated sewage treatment construction.

The restoration of an important water use as a result of effective pollution abatement is reported in the case of the Bluepoint Oyster industry (12) in Moriches Inlet and Great South Bay on Long Island. Pollution from Long Island duck farms had practically wiped out the oyster industry. Abatement proceedings initiated by the State in 1951 together with a flush-out of Moriches Inlet by the 1953 hurricane have combined to restore this area to favorable environment for the Bluepoint oyster.

Hoak (81) discusses a rational program for stream pollution control. He feels there is no direct evidence that stream pollution is a significant health factor and calls upon state water pollution control agencies to apply the principle that treatment should be provided only to the extent that it will adequately protect downstream uses in the receiving water. He cites the need for the establishment of criteria to better define the effects of pollution on various water uses and points out that the single most important factor in pollution abatement is education -- as the benefits of the abatement program are properly explained, funds necessary to finance construction in order to maintain these benefits will be forthcoming.

Wisdom (208) presents an excellent and comprehensive review of English water pollution law and Lovett (119) points out that the enactment of legislation alone does not insure abatement of pollution. A realistic approach and proper appreciation of the need for a policy of true conservation of water resources is essential.

The pollution of surface waters in 18 European countries is discussed by Key (100). This very excellent summary supplies information on population, industries, water quality, legal and administrative control measures, waste treatment facilities, sewage, and special national and international problems for these several countries. The story of gross pollution in Europe is largely the story of industrial areas. However, serious problems resulting from bacterial pollution from domestic sewage are prevalent in small localized areas. The author observes that the pollution problem may be expected to increase as the general standard of living increases and the final and permanent solution cannot now be foreseen. The most difficult pollution control problems appear to be associated with the paper and allied industries. Other important industries are sugar beet, dairy products, gas and coke, textiles, mining and metallurgical.

In discussing pollution prevention philosophies and conflicts of interest the author notes that several European countries have laws a century or more old designed to protect fish from the effects of pollution. The author points out that this may be understandable since the disappearance of fish is often the most obvious effect of pollution and needs no scientific test to establish the fact. The observation is made, however, that over-stressing of this point may be in conflict with other uses that may be more beneficial to mankind. The point is made that often unrealistic laws have not prevented pollution. All of these facts point up the need for better definition of the aims of pollution prevention in

European countries. In many instances mistakes of ignorance were made which now can be rectified only at an enormous expense. Had present developments been foreseen definite approaches to protecting the water resources would no doubt have been applied. Newly developing countries should benefit from these unfortunate past experiences.

Tsivoglou and Towne (190) call attention to the need for state water pollution control agencies to assume increased responsibilities in the control of radioactive discharges to surface waters. The desirability of basin-wide planning in establishing control measures is emphasized.

Additional References

1. Anon., "Ohio River Cleanup Progress." Amer. City, 72, 6, 33 (1957).
2. Anon., "165 Additional Municipalities Get Sewage Treatment Grants." Amer. City, 72, 9, 171 (1957).
3. Evests, C. M., and Dahl, A. H., "The Federal Water Pollution Control Act of 1956." Amer. Jour. Pub. Health, 47 (3), 305, (1957).
4. Hatch, N. E., "Hocking River Pollution Ends." Amer. City, 72, 1, 129 (1957).
5. Hess, R. W., "Niagara River Pollution." Jour. San. Eng. Div., Proc. Amer. Soc. Civil Engrs., 83, 1410 (1957).
6. Kovrigina, M. D., "The Fight Against Pollution of Water in the U.S.S.R." Stadtehygiene(Germany) 7, 103 (1956); Water Poll. Abs., 29, 430 (1956); Pub. Health Eng. Abs., 37, 8, 25 (1957).
7. Young, L. A., "The U.S.P.H.S. Stream Pollution Abatement Program." Jour. San. Eng. Div., Proc. Amer. Soc. Civil Engrs., 83, 1338 (1957).

REFERENCES

1. Adams, R. B., "Comparison of Standard Dilution and Membrane Filter Methods." Jour. Amer. Water Wks. Assn., 49, 1452 (1957).

2. Alabaster, J. S., Herbert, D. W. M., and Hemens, J., "The Survival of Rainbow Trout (Salmo gairdnerii Richardson) and Perch (Perca fluviatilis L.) at Various Concentrations of Dissolved Oxygen and Carbon Dioxide." Ann. Appl. Biol. (Brit.), 45, 1, 177 (1957).

3. Alderdice, D. F., and Brett, J. R., "Some Effects of Kraft Mill Effluent on Young Pacific Salmon." Fish. Res. Bd. of Canada, 14, 783 (1957).

4. Alderdice, D. F., and Brett, J. R., "Toxicity of Sodium Arsenite to Young Chum Salmon." Fish. Res. Bd. of Canada, Progr. Repts. of the Pacific Coast Stas., No. 108, 27 (1957).

5. Anon., "Fifth Statutory Annual Report for the Year Ended 31st March, 1955." Bristol Avon River Bd., Water Poll. Abs. (Brit.), 29, 318 (1956).

6. Anon., "Controlling Another River Pollutant: Salt." Eng. News-Rec., 159, 3, 30 (1957).

7. Anon., "Disposal of Power-station Ash into the Sea." Surveyor, 116, 1073 (1957).

8. Anon., "Freshwater Biological Association. 23rd Annual Report for the Year Ended 31st March, 1955." Freshwater Biol. Assn., Water Poll. Abs. (Brit.), 29, 338 (1956).

9. Anon., "Pollution Dangers to London Water Supplies." Surveyor, 116, 11 (1957).

10. Anon., "Pollution of Streams in the German Republic, Effects and Possibilities of Removal." Deutsche Akademic der Landwirtschaftswissenschaften Zu Berlin Sitzungsherichte, 3, 2 (1954); Lit. Ber. Wass. Abwass. Luft u. Boden, 5, 47 (1956); Water Poll. Abs. (Brit.), 30, 4, 141 (1957).

11. Anon., "Report on Oily Substances and Their Effects on the Beneficial Uses of Water." Calif. Water Poll. Control Bd., Pub. No. 16, 72 (1956); Pub. Health Eng. Abs., 37, 9, 24 (1957).

12. Anon., "The Blue Point Oyster Grows Again." Eng. News-Rec., 158, 13, 43 (1957).

13. Anon., "Water Supplies Must be Protected Against Nuclear Reactor Operations." Water Wks. Eng., 110, 534 (1957).

14. Applegate, V. C., Howell, J. H., Hall, A. E., Jr., and Smith, M. A., "Toxicity of 4,346 Chemicals to Larval Lampreys and Fishes." Fish and Wildlife Serv., Sp. Sci. Rept. Fish., No. 207, 157 (1957).

15. Banarjea, S., Motwani, M. P., and Karamchandani, S. J., "A Case of Heavy Fish Mortality in the River Sone at Dehri-on-Sone, Bihar, Caused by the Wastes of the Rohtas Industries, Ltd., Dalmianagar." Indian Jour. of Fish., 3, 186 (1956).

16. Baxter, S. S., "More Sewage for the Plant--Less for the River." Amer. City, 72, 6, 125 (1957).

17. Beak, T. W., "Biology and Water Pollution in Great Britain." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 220 (1957).

18. Beck, W. M., Jr., "The Use and Abuse of Indicator Organisms." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 175 (1957).

19. Boroughs, H., Townsley, S. J., and Hiatt, R. W., "The Metabolism of Radionuclides by Marine Organisms. I. The Uptake, Accumulation, and Loss of Strontium-89 by Fishes." Biol. Bull. Wood's Hole, 111, 336 (1956); Water Poll. Abs. (Brit.), 30, 177 (1957).

20. Boroughs, H., Townsley, S. J., and Hiatt, R. W., "The Metabolism of Radionuclides by Marine Organisms. II. The Uptake, Accumulation, and Loss of Yttrium-91 by Marine Fish, and the Importance of Short-Lived Radionuclides in the Sea." Biol. Bull., 111, 352 (1956); Water Poll. Abs. (Brit.), 30, 177 (1957).

21. Brebion, G., Chopin, J., and Humbert, F., "Toxicity to Fish (Minnows) of Some Phenolic Derivatives Formed by the Decomposition of Lignin in Paper Pulp Factories." Chim. et Industr. (France), 77, 1110 (1957); Water Poll. Abs. (Brit.), 30, 285 (1957).

22. Bringmann, G., and Kuhn, R., "The Algal Titre as a Criterion of Eutrophication in Water and Mud." Gesundh. Ing. (Germany), 77, 374 (1956); Water Poll. Abs. (Brit.), 30, 70 (1957).

23. Buck, H. D., "Effects of Turbidity on Fish and Fishing." Trans. of the Twenty-first N. Amer. Wildlife Conf., 249 (1956).

24. Burden, E. H. W. J., "A Case of DDT Poisoning in Fish." Nature (Brit.), 178, 546 (1956); Water Poll. Abs. (Brit.), 30, 71 (1957).

25. Burdick, G. E., "A Graphical Method for Deriving Threshold Values of Toxicity and the Equation of the Toxicity Curve." N. Y. Fish and Game Jour., 4, 1, 102 (1957).

26. Burdick, G. E., Dean, H. J., and Harris, E. J., "Lethal Oxygen Concentrations for Yellow Perch." N. Y. Fish and Game Jour., 4, 1, 92 (1957).

27. Burt, W. V., and Marriage, L. D., "Computation of Pollution in the Yaquina River Estuary." THIS JOURNAL, 29, 12, 1385 (Dec., 1957).

28. Cairns, J., Jr., "Environment and Time in Fish Toxicity." Ind. Wastes, 2, 1, 1 (1957).

29. Cairns, J., Jr., and Scheier, A., "The Effects of Temperature and Hardness of Water Upon the Toxicity of Zinc to the Common (sic) Bluegill (Lepomis macrochirus Raf.)" Notulae Naturae, No. 299, 11 (1957).

30. Chacko, P. I., and Srinivasan, R., "Fish Mortality in the Rock Pools of a Quarry Near Virudhunagar (Ramanathapuran District), Madras." Proc. Indian Acad. Sci., 29, B, 91 (1954); Water Poll. Abs. (Brit.), 30, 286 (1957).

31. Christenson, C. W., Rex, E. H., Webster, W. M., and Vigil, F. A., "Reduction of Nitrate Nitrogen by Modified Activated Sludge." (Los Alamos Sci. Labs., N. Mex.), U. S. Atomic Energy Comm. TID-7517 Part 1a, 264 (1956).

32. Clark, H. F., Kabler, P. W., and Geldreich, E. E., "Advantages and Limitations of the Membrane Filter Procedure." Water and Sew. Wks., 104, 385 (1957).

33. Cleary, E. J., "9th Annual Summary - 1957." Ohio River Valley Water Sanitation Commission, Cincinnati, Ohio.

34. Clemens, H. P., and Finnell, J. C., "Biological Conditions in a Brine-Polluted Stream in Oklahoma." Trans. Amer. Fish. Soc., 85, 18 (1957).

35. Cole, H. A., "Oyster Cultivation in Britain, a Manual of Current Practice." Ministry of Agr. Fish. and Food (Brit.), 43 (1956); Pub. Health Eng. Abs., 37, 5, 22 (1957).

36. Collin, V. G., and Kipling, C., "The Enumeration of Water-borne Bacteria by a New Direct Count Method." Jour. Appl. Bact., 20, 257 (1957).

37. Combs, B. D., and Burrows, R. E., "Threshold Temperatures for the Normal Development of Chinook Salmon Eggs." Progressive Fish Culturist, 19, 1, 3 (1957).

38. Cooke, W. B., "Use and Value of Fungi as Biological Indicators of Pollution." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 84 (1957).

39. Cooke, W. B., and Busch, K. A., "Activity of Cellulose-Decomposing Fungi Isolated from Sewage-Polluted Water." THIS JOURNAL, 29,2, 210 (Feb., 1957).

40. Cooke, W. B., and Kabler, P. W., "Plant Disease Fungi in Sewage Polluted Water." Pub. Health Repts., 72, 651 (1957).

41. Corner, E. D. S., and Sparrow, B. W., "The Modes of Action of Toxic Agents. I. Observations on the Poisoning of Certain Crustaceans by Copper and Mercury." Jour. Mar. Biol. Assn. U. K. (Brit.), 35, 531 (1956); Water Poll. Abs. (Brit.), 30, 71 (1957).

42. Corner, E. D. S., and Sparrow, B. W., "The Modes of Action of Toxic Agents. II. Factors Influencing the Toxicities of Mercury Compounds to Certain Crustacea." Jour. Mar. Biol. Assn. U. K. (Brit.), 36, 459 (1957).

43. Cushing, C. E., Jr., and Olive, J. R., "Effects of Toxaphene and Rotenone Upon the Macroscopic Bottom Fauna of Two Northern Colorado Reservoirs." Trans. Amer. Fish. Soc., 86, 294 (1957).

44. Dauer, C. C., and Sylvester, G., "1956 Summary of Disease Outbreaks." Pub. Health Repts., 72, 735 (1957).

45. David, A., "Studies on the Pollution of the Bhadra River Fisheries at Bhadravathi (Mysore State) with Industrial Effluents." Proc. Natl. Inst. Sci. India, 22, B, 3, 132 (1957).

46. DeWitt, J. W., "Mortality of Aquatic Insects and Fishes Caused by Use of Latex Tubing in Experimental Apparatus." Science, 126, 3278, 840 (1957).

47. Doudoroff, P., and Warren, C. E., "Biological Indices of Water Pollution, With Special Reference to Fish Populations." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 144 (1957).

48. Downing, K. M., and Merkens, J. C., "The Influence of Temperature on the Survival of Several Species of Fish in Low Tensions of Dissolved Oxygen." Ann. Appl. Biol. (Brit.), 45, 261 (1957).

49. Ellis, R. J., and Gowing, H., "Relationship Between Food Supply and Condition of Wild Brown Trout, Salmo trutta Linnaeus, in a Michigan Stream." Limn. and Ocean., 2, 299 (1957).

50. Ettinger, M. B., "Biochemical Oxidation Characteristics of Stream-Pollutant Organics." Ind. Eng. Chem., 48, 256 (1956).

51. Felsenfeld, O., and Rokkaku, W. K., "Adaptation of the Membrane Filter Technique to the Recovery of Vibrio Comma from Water Samples." Jour. Bact., 72, 869 (1956).

52. Fetner, R. H., and Ingols, R. S., "A Comparison of the Bactericidal Activity of Ozone and Chlorine Against Escherichia coli at 1°." Jour. Gen. Microbiol., 15, 381 (1956); Pub. Health Eng. Abs., 37, 1, 28 (1957).

53. Fijiwara, T., Gohara, Y., Matasi, T., and Oya, S., "On the Poisoning Water in the North-Eastern Side of Yatsugatake Volcanoes, Nagano Prefecture." Misc. Rept. Res. Inst. Natl. Resources Tokyo (Japan), No. 36, 32 (1954); Pub. Health Eng. Abs., 35, 7, 19 (1956); Water Poll. Abs. (Brit.), 30, 4, 142 (1957).

54. Fournelle, H. J., "Determining Potability of Water Supplies in the Field." U. S. Armed Forces Med. Jour., 8, 713 (1957).

55. Fournelle, H. J., and Page, W. B., "Experimental Ground Water Pollution at Anchorage, Alaska." Pub. Health Repts., 72, 203 (1957).

56. Friberg, L., and Hammarstrom, E., "The Effect of Free Available Chlorine on Bacteria and Bacterial Viruses." Nord. Hyg. Tidskr., 37, 1 (1956); Jour. Amer. Water Wks. Assn., 49, 7, 66 (1957).

57. Gaby, W. L., and Hadley, C., "Practical Laboratory Test for the Identification of Pseudomonas aeruginosa." Jour. Bact., 74, 356 (1957).

58. Galtsoff, P. S., "Ecological Changes Affecting the Productivity of Oyster Grounds." Trans. 21st N. Amer. Wildlife Cong., 408 (1956).

59. Gameson, A. L. H., and Preddy, W. S., "Factors Affecting the Concentration of Dissolved Oxygen in the Thames Estuary." Jour. and Proc., Inst. Sew. Purif., Part 4, 322 (1956).

60. Gameson, A. L. H., "Weirs and the Aeration of Rivers." Jour. Inst. Water Engrs. (Brit.), 11, 6, 477 (1957).

61. Garrett, J. T., "Toxicity Investigations on Aquatic and Marine Life." Pub. Wks., 88, 12, 95 (1957).

62. Garrett, J. T., "Toxicity Considerations in Pollution Control." Ind. Wastes, 2, 1, 17 (1957).

63. Gaufin, A. R., "The Use and Value of Aquatic Insects as Indicators of Organic Enrichment." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 136 (1957).

64. George, J. L., Darsie, R. F., Jr., and Springer, P. F., "Effects on Wildlife of Aerial Applications of Strobane, DDT, and BHC to Tidal Marshes in Delaware." Jour. Wildlife Mgt., 21, 42 (1957); Wildlife Rev., 88, 7 (1957).

65. Gibson, M. B., and Hirst, B., "The Effect of Salinity and Temperature on the Pre-adult Growth of Guppies." Copeia, 3, 241 (1955).

66. Gohar, M. A., and Eissa, A. A., "The Use of Membrane Filters in the Bacteriological Examination of Water and Air." Z. Hyg. Infekt. Kr., 143, 364 (1957); Water Poll. Abs. (Brit.), 30, 265 (1957).

67. Gol'dfarb, D. M., "Detection of Dysentery Bacteria in Artificially Infected Water by the Phage Titre Increase Reaction." Jour. Microbiol., Epidem. and Immun., 28, 24 (1957).

68. Greenberg, A. E., and Kupka, E., "Tuberculosis Transmission by Waste Waters - A Review." THIS JOURNAL, 29, 5, 524 (May, 1957).

69. Greenberg, A. E., Wickenden, R. W., and Lee, T. W., "Tracing Typhoid Carriers by Means of Sewage." THIS JOURNAL, 29, 11, 1237 (Nov., 1957).

70. Guelin, A., "The Contamination of Fishes and the Problem of Water Pollution." Ann. Inst. Pasteur (France), 86, 303 (1954); Jour. Mar. Biol. Assn. U. K. (Brit.), 36, 2, 435 (1957).

71. Halsband, E., "A New Method of Measuring Frequency of Respiration for Investigating the Effect of Poisons in Waste Waters." Arch. Hydrobiol., Suppl. 22, 323 (1955); Water Poll. Abs. (Brit.), 30, 71 (1957).

72. Hartman, O., "Contributions to a Biological Survey of Santa Monica Bay, California." Allan Hancock Foundation for Sci. Res., Univ. of Southern Calif., 163 (1956).

73. Hatch, R. W., "Relative Sensitivity of Salmonids to DDT." Progressive Fish Culturist, 19, 89 (1957).

74. Hatfield, R., "Biological Oxidation of Some Organic Compounds." Ind. Eng. Chem., 49, 192 (1957).

75. Hawkes, H. A., "The Biological Assessment of Pollution in Birmingham Streams." Jour. and Proc., Inst. Sew. Purif., Part 2, 177 (1956).

76. Henderson, C., "Application Factors to be Applied to Bio-assays for the Safe Disposal of Toxic Wastes." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 31 (1957).

77. Henderson, C., and Tarzwell, C. M., "Bio-assays for Control of Industrial Effluents." THIS JOURNAL, 29, 9, 1002 (Sept., 1957).

78. Hendriksen, S. D., "Further Studies on Coliform Tests on Water Carried at 30°C and at 39°C." Acta Pathol. et Microbiol. Scand., 38, 2, 101 (1956); Biol. Abs., 30, 3538 (1956); Pub. Health Eng. Abs., 37, 6, 30 (1957).

79. Herbert, D. W. M , Elkins, G. H. J., Mann, H. T., and Hemens, J., "Toxicity of Synthetic Detergents to Rainbow Trout." Water and Waste Treatment Jour., 6, 9, 394 (1957).

80. Heukelekian, H., et al., "Symposium on Purifying Chemically Polluted Waters." Ind. Eng. Chem., 48, 1403 (1956).

81. Hoak, R. D., "A Rational Program for Stream Control." Ind. Wastes, 2, 88 (1957).

82. Holluta, J., "Substances Affecting Taste and Odour of Bank-filtered Water Supplies and Their Removal." Kommulalwirtschaft (Germany), No. 213, 62 (1955); LitBer. Wass. Abwass. Luft u. Boden, 4, 298 (1955); Water Poll. Abs. (Brit.), 30, 1, 36 (1957).

83. Holluta, J., and Talsky, J., "The Chromatographic Determination of Organic Substances in Natural Waters." Vom Wasser (Germany), 22, 212 (1955); Water Poll. Abs. (Brit.), 30, 6, 197 (1957).

84. Hooper, F. F., and Grzenda, A. R., "The Use of Toxaphene as a Fish Poison." Trans. Amer. Fish. Soc., 85, 180 (1957).

85. Huet, M., "Water Requirements for Fish Breeding." Bull. Centre Belge Etude et Document. Eaux (Belgium), 28, 108 (1955); Water Poll. Abs. (Brit.), 30, 191 (1957).

86. Hulsey, A. H., "A Statewide Fisheries Survey." Dingell-Johnson Quart., 6, 1, 1 (1957).

87. Ide, F. P., "Effect of Forest Spraying With DDT on Aquatic Insects of Salmon Streams." Trans. Amer. Fish. Soc., 86, 208 (1957).

88. Ingols, R. S., "Pollutional Effects of Hydraulic Power Generation." THIS JOURNAL, 29, 3, 292 (Mar., 1957).

89. Ingram, W. M., "Use and Value of Biological Indicators of Pollution: Fresh Water Clams and Snails." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 94 (1957).

90. Ingram, W. T., "Pollution Problems in Tidal Estuaries." Proc. 5th Ann. Water Symposium, La. State Univ., Eng. Exp. Sta. Bull., No. 55, 99 (1956).

91. Jaag, O., "Pollution of Flowing Waters, Illustrated by the Example of the River Rhine." Ber. Abwassertechnischen Vereinigung No. 6. R. Oldenbourg, Munich (Germany), (1955); Water Poll. Abs. (Brit.), 30, 287 (1957).

92. Kabler, P. W., "Use and Value of Bacterial Indicators of Pollution." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 43 (1957).

93. Kaplovsky, A. J., "Estuarine Pollution Investigation Employing 'Same-Slack' Technique." THIS JOURNAL, 29, 9, 1042 (Sept., 1957).

94. Karakasevic, B., "Culture Media for the Bacteriologic Examination of Drinking Water." Godisen Zbornik na Medicinskiot Fakultet jo Skopje (Yougoslavia), 1, 63 (1954); Eau (France), 44, 7 (1957).

95. Kawabe, K., and Tomiyama, T., "Studies on Purification of Industrial Wastes.--IV. Treatment of Wasted Bleaching Liquor in a Paper Mill." Bull. Japan Soc. Sci. Fisheries, 20, 1086 (1955); Pub. Health Eng. Abs., 37, 11, 17 (1957).

96. Kazuaki, I. E., "On the Pollution of River and Drinking Water by the Wastes of Starch Plant. Studies on the Pollution of the River Water." Shikoku Acta Med. (Japan), 8, 5, 6 (1956); Excerpta Medica, Public Health, Social Med. and Hyg., 3, 224 (1957); Pub. Health Eng. Abs., 37, 8, 24 (1957).

97. Kelly, S., and Sanderson, W. W., "Chlorination of Poliovirus." Science, 126, 560 (1957).

98. Kenner, B. A., and Kabler, P. W., "Members of the Tribe Mimeae Isolated from River Water." Jour. Bact., 72, 870 (1956).

99. Kenner, B. A., Rockwood, S. W., and Kabler, P. W., "Isolation of Members of the Genus Salmonella by Membrane Filter Procedures." Applied Microbiol., 5, 305 (1957).

100. Key, A., "Pollution of Surface Water in Europe." Bull. World Health Organization, 14, No. 5-6, 845 (1956); Pub. Health Eng. Abs., 37, 3, 24 (1957).

101. Kirkwood, J. B., "A Brief Study of the Levisa Fork and Russell Fork of the Big Sandy River." Div. of Fisheries, Dept. of Fish and Wildlife Res., Frankfort, Ky., Fisheries Bull. 21, 1 (1957).

102. Klock, J. W., "A Field Technique for Quantitative Estimation of the Molluscicide Sodium Pentachlorophenate Based on Fish Mortality Rates." Amer. Jour. Trop. Med., 5, 286 (1956); Water Poll. Abs. (Brit.), 30, 51 (1957).

103. Koenuma, A., "The Effect of Uranyl Nitrate on Fertilization in Urechis unicinctus, and Hemicentrotus pulcherrimus." Dobutsugaku Zasshi (Japan), 65, 281 (1956); Chem. Abs., 51, 15016 (1957).

104. Krumholz, L. A., "Observations on the Fish Population of a Lake Contaminated by Radioactive Wastes." Bull. Amer. Mus. Natl. Hist., 110, 277 (1956); Water Poll. Abs. (Brit.), 30, 34 (1957).

105. Lackey, J. B., "Protozoa as Indicators of the Ecological Condition of a Body of Water." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 50 (1957).

106. Ladendorf, A., and Ladendorf, K., "Chlorine Dioxide for Disinfecting and Purifying Water." Jour. Sci. Food Agr. (Brit.), 8, 112 (1957); Pub. Health Eng. Abs., 37, 9, 31 (1957).

107. Laycock, H. C., "Cetyl Alcohol Controls Evaporation." Water and Sew. Wks., 103, 346 (1956); Pub. Health Eng. Abs., 37, 3, 29 (1957).

108. Leclerc, E., Beaujean, P., and Devlaminck, F., "River Pollution. Calculation and Measurement of the Capacity of Self-Purification of Fermentable Organic Matter." Rev. Tech. Luxembourg, 48, 174 (1956); Chem. Abs., 51, 645 (1957); Pub. Health Eng. Abs., 37, 9, 25 (1957).

109. Leclerc, E., and Beeckmans, I., "Studies of Rivers by Cebedeau, Especially that of the Sambre." Bull. Centre Belge Etude et Document. Eaux (Belgium), 73, 20 (1957); Pub. Health Eng. Abs., 37, 11, 22 (1957).

110. Leclerc, E., Beaujean, P., and Heuse, M. R., "The Study of the Pollution of a River and its Self-Purification. Application of a Research Method to the Geer River." Bull. Centre Belge Etude et Document. Eaux (Belgium), 33, 142 (1956); Pub. Health Eng. Abs., 37, 10, 17 (1957).

111. Leclerc, E., and Devlaminck, F., "Fish Toxicity Tests and Water Quality." Bull. Centre Belge Etude et Document. Eaux (Belgium), 28, 111 (1955); Water Poll. Abs. (Brit.), 30, 215 (1957).

112. Leggiero, M., "The Pollution Control Act - A Year Later." Eng. News-Rec., 159, 7, 25 (1957).

113. Leiguarda, H., et al., "Streptococci as Indicators of Water Pollution." Rev. Obras. San. de la Nacion (Spain), 20, 168, 166 (1956); Bull. Hyg., 32, 471 (1957); Pub. Health Eng. Abs., 37, 12, 24 (1957).

114. LeStrat, A., "Pollution of Waters by Detergent Products." Eau (France), 43, 272 (1956).

115. Levin, G. V., Harrison, V. R., and Hess, W. C., "Use of Radioactive Culture Media." Jour. Amer. Water Wks. Assn., 49, 1069 (1957).

116. Libosvarsky, J., "A Contribution to the Knowledge of Larvae of Trichopterae in the River Moravice, Especially Regarding the Purity of Water." Sbornik Vysoke Skoly Zemed. Brno A. Spisy Fak. Agron. a Zootech. (Czechoslavakia), 2, 161 (1955); Biol. Abs., 31, 369 (1957).

117. Liebmann, H., "Sewage Notebook." Arb. Dtsch. Fisch.-Verband Munich (Germany), No. 5, 4th Ed. (1954); Water Poll. Abs. (Brit.), 29, 431 (1956).

118. Liepolt, R., "Pollution of Streams and Examination of Waste Waters with Special Reference to Fisheries." Mitt. Ost. Sanitatsverwaltung (Germany), 56, 5 (1955); Water Poll. Abs. (Brit.), 29, 287 (1956); Pub. Health Eng. Abs., 37, 9, 25 (1957).

119. Lovett, M., "The Campaign for Cleaner Rivers." Surveyor, 116, 101 (1957).

120. Lowe, H. N., and Lindsten, D. C., "Removal of CBR Contaminants from Water." Mil. Surg., 121, 330 (1957).

121. Ludzack, F. J., and Ettinger, M. B., "Biological Oxidation of Hexadecanol Under Laboratory Conditions." Jour. Amer. Water Wks. Assn., 49, 849 (1957).

122. Ludzack, F. J., Ingram, W. M., and Ettinger, M. B., "Characteristics of a Stream Composed of Oil Refinery and Activated Sludge Effluents." THIS JOURNAL, 29, 10, 1177 (Oct., 1957).

123. Ludzack, F. L., and Kinkead, D., "Persistence of Oily Wastes in Polluted Water Under Aerobic Conditions." Ind. Eng. Chem., 48, 263 (1956).

124. Lueck, B. F., Wiley, A. J., Scott, R. H., and Wisniewski, T. F., "Determination of Stream Purification Capacity." THIS JOURNAL, 29, 9, 1054 (Sept., 1957).

125. Lyman, F. E., "Environmental Factors Affecting Distribution of Mayfly Nymphs in Douglas Lake, Michigan." Ecology, 37, 568 (1956); Water Poll. Abs. (Brit.), 29, 338 (1956).

126. McCallum, G. E., "A Progress Report on the First Year of the Grants Program for Construction of Sewage Treatment Works." Pub. Wks., 88, 10, 139 (1957).

127. McCarthy, J. A., "Storage of Water Samples for Bacteriologic Examination." Amer. Jour. Pub. Health, 47, 971 (1957).

128. McLeese, D. W., "Effects of Temperature, Salinity, and Oxygen on the Survival of the American Lobster." Jour. Fish. Res. Bd. Can., 13, 247 (1956); Water Poll. Abs. (Brit.), 29, 374 (1956).

129. Mackenthun, K. M., "Current Water Pollution Investigations and Problems in Wisconsin." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 179 (1957).

130. Mann, H., "Behaviour of Sewage in Tidal Waters, Illustrated by the Example of the Elbe." Arb. Dtsch. Fisch.-Verband Munich (Germany), No. 7, 8 (1956); Litber. Wass. Abwass. Luft u. Boden, 5, 168 (1956); Water Poll. Abs. (Brit.), 30, 7, 251 (1957).

131. Meehan, O. L., "Effect of Pollution upon Wildlife." Biol. Problems in Water Poll. Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 240 (1957).

132. Merkens, J. C., "Controlled Aqueous Environments for Bioassay." Laboratory Practice, 6, 8, 456 (1957).

133. Merkens, J. C., and Downing, K. M., "The Effect of Tension of Dissolved Oxygen on the Toxicity of Un-ionized Ammonia to Several Species of Fish." Ann. Appl. Biol. (Brit.), 45, 521 (1957).

134. Meuwis, A. L., and Heuts, M. J., "Temperature Dependence of Breathing Rate in Carp." Biol. Bull., 112, 97 (1957); Water Poll. Abs. (Brit.), 30, 229 (1957).

135. Middleton, F. M., and Rosen, A. A., "Organic Contaminants Affecting the Quality of Water." Pub. Health Repts., 71, 1125 (1956).

136. Mills, E. J., and Stack, V. T., "Biological Oxidation Parameter Applied to Industrial Wastes." Ind. Eng. Chem., 48, 260 (1956).

137. Monod, R., "A Contribution to the Study of the Variations of the Chemical Composition of the Waters of Lake Geneva - Phenomena of Pollution and Self-Purification at the Mouth of the Flon at Vidy." Ann. Sta. Cent. Hydrobiol. Appl., 6, 231 (1956); Water Poll. Abs. (Brit.), 30, 6, 193 (1957).

138. Motwani, M. P., Banerjea, S., and Karamchandani, S. J., "Some Observations of the Pollution of the River Sone by the Factory Effluents of the Rohtas Industries at Dalmianagar (Bihar)." Indian Jour. Fisheries, 3, 334 (1956).

139. Muller, W., "Preventing Deterioration of Streams in Densely Populated Districts." Gas u. Wasserfach (Germany), 97, 944 (1956); Water Poll. Abs. (Brit.), 30, 8, 288 (1957).

140. Neel, J. K., "Some Aspects of Water Pollution in the Missouri Basin." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 209 (1957).

141. Neil, J. H., "Investigations and Problems in Ontario." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 184 (1957).

142. Nelson, P. R., and Edmondson, W. T., "Limnological Effects of Fertilizing Bare Lake, Alaska." Fish. Bull., U. S. Fish and Wildl. Serv., 56, 415 (1955); Waten Poll. Abs. (Brit.), 30, 194 (1957).

143. Nickerson, W. J., "Transformations of Carbon Compounds by Microorganisms." Ind. Eng. Chem., 48, 1411 (1956).

144. Njoku-Obi, A., and Skinner, C. E., "Boric Acid Lactose Broth as a Medium for the Detection of Fecal Coliform Bacteria." Applied Microbiol., 5, 80 (1957).

145. Noisette, G., "Pollution of the Waters of Various Rivers of the East (of France)." Eau (France), 43, 281 (1956).

146. O'Connor, D. J., and Dobbins, W. E., "The Mechanism of Reaeration in Natural Streams." Proc. Amer. Soc. Civil Engrs., 82, Jour. San. Eng. Div., Paper No. 1115 (1956).

147. Opheim, B. R., "Southwest Montana Fishery Study." Dingell-Johnson Quart., 6, 1, 43 (1957).

148. Palmer, C. M., "Algae as Biological Indicators of Pollution." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 60 (1957).

149. Papavassiliou, J., and Wegner, K. H., "Membrane Filter Method for Detection of Sulfite-Reducing Clostridia in Water and Other Liquids." Zbl. Bakt., I, Orig. (Germany), 167, 383 (1957); Water Poll. Abs. (Brit.), 30, 155 (1957).

150. Patrick, R., "Diatoms as Indicators of Changes in Environmental Conditions." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 71 (1957).

151. Patrick, R., and Hohn, M. H., "The Diatometer -- a Method for Indicating the Conditions of Aquatic Life." Proc. Amer. Petroleum Inst., 36, 332 (1956).

152. Philipson, G. N., "The Effect of Water Flow and Oxygen Concentration on Six Species of Caddis Fly (Trichoptera) Larvae." Proc. Zoological Soc. London (England), 124, 547 (1954).

153. Pillai, S. C., Mohanrao, G. J., and Sastry, C. A., "Self-Purification of Sewage-Polluted Waters." Indian Med. Profess., 3, 1513 (1957).

154. Podubsky, V., and Stredronsky, E., "The Effect of Zinc on Fish Spawn and Young Fish and on Daphnia in Water of Different Degrees of Hardness." Ann. Acad. Tchecosl. Agric. (Czechoslavakia), 25, 441 (1952); Water Poll. Abs. (Brit.), 29, 322 (1956).

155. Prosser, C. L., Barr, L. M., Pinc, R. D., and Lauer, C. Y., "Acclimation of Goldfish to Low Concentrations of Oxygen." Physiological Zoology, 30, 2, 137 (1957).

156. Rand, M. C., "Concepts of Surface Reaeration - A Critical Review." THIS JOURNAL, 29, 11, 1282 (Nov., 1957).

157. Rand, M. C., "Surface Reaeration of Water as Affected by Domestic Sewage." Pub. Wks., 88, 12, 92 (1957).

158. Reis, J. H., "Current Investigations in Water Pollution Biology. Investigations and Problems in Ohio." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 215 (1957).

159. Reish, D. J., "Effects of Pollution on Marine Life." Ind. Wastes, 2, 5, 114 (1957).

160. Reish, D. J., "The Relationship of the Polychaetous Annelid, Capitella capitata (Febricus) to Waste Discharges of Biological Origin." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 195 (1957).

161. Reitler, R., and Seligmann, R., "Pseudomonas aeruginosa in Drinking Water." Jour. Appl. Bact., 20, 145 (1957).

162. Richter, J., "Salmonellae in Sewage: A Local Sewage Problem (Salmonellen im Vorfluter: ein orthliches Abwasserproblem)." Stadtehyg. (Germany), 7, 101 (1956); Bull Hyg., 31, 1027 (1956); Pub. Health Eng. Abs., 37, 6, 17 (1957).

163. Robson, J. E., "A Bacterial Method for Tracing Sewage Pollution." Jour. Appl. Bact., 19, 243 (1956); Pub. Health Eng. Abs., 37, 9, 25 (1957).

164. Rudd, R. L., and Genelly, R. E., "Pesticides: Their Use and Toxicity in Relation to Wildlife." Calif. Dept. Fish & Game, Game Bull., 7, 1 (1956).

165. Saiki, M., and Mori, T., "Studies on the Distribution of Administered Radioactive Zinc in the Tissues of Fishes. I." Bull. Japan Soc. Sci. Fisheries, 21, 945 (1955); Biol. Abs., 31, 2196 (1957).

166. Sawyer, C. N., Bogan, R. H., and Simpson, J. R., "Biochemical Behavior of Synthetic Detergents." Ind. Eng. Chem., 48, 236 (1956).

167. Sawyer, C. N., and Ryckman, D. W., "Anionic Synthetic Detergents and Water Supply Problems." Jour. Amer. Water Wks. Assn., 49, 4, 480 (1957).

168. Schiavone, E. L., and Passerini, L. M. D., "Preliminary Notes on the Use of Membrane Filters in the Bacteriologic Examination of Water. Some Results." Rev. Argentina Biochem. Assn., 22, 86 (1957).

169. Schmid, ., "The Schliersee, an Example of Damage by Sewage." Fischwirt (Germany), 6, 3, 68 (1956); LitBer. Wass. Abwass. Luft u. Boden, 5, 50 (1956); Water Poll. Abs. (Brit.), 30, 72 (1957).

170. Schmitz, W., "Salzgehaltschwankungen im der Werra und ihre Fischereilichen Auswirkungen." Vom Wasser (Germany), 23, 113 (1957).

171. Schneller, M. V., "Oxygen Depletion in Salt Creek, Indiana." Invest. Ind. Lakes & Streams, 4, 163 (1955); Water Poll. Abs. (Brit.), 30, 5, 178 (1957).

172. Scidmore, W. J., "An Investigation of Carbon Dioxide, Ammonia, and Hydrogen Sulfide as Factors Contributing to Fish Kills in Ice-Covered Lakes." Progressive Fish Culturist, 19, 3, 124 (1957).

173. Scott, R. H., Wisniewski, T. F., Lueck, B. F., and Wiley, A. J., "Organization of Cooperative State-Industry Stream Studies in Wisconsin." THIS JOURNAL, 29, 298 (Mar., 1957); Pub. Health Eng. Abs., 37, 12, 21 (1957).

174. Shapiro, R., "Pollution Survey Sampling of New York Harbor." THIS JOURNAL, 28, 1504 (Dec., 1956); Pub. Health Eng. Abs., 37, 10, 21 (1957).

175. Shaw, W. H. R., and Grushkin, B., "The Toxicity of Metal Ions to Aquatic Organisms." Arch. Biochem. and Biophys., 67, 2, 447 (1957).

176. Spies, K. H., "$50 Million Spent for Stream Purity." Oregon Health Bull., 35, 4, 4 (1957).

177. Steiniger, F., "The Necessity for Taking Account of Free-Living Typhoid-Paratyphoid Bacteria in Sewage Technology." Vom Wasser (Germany), 21, 172 (1954); Water Poll. Abs. (Brit.), 29, 141 (1956); Pub. Health Eng. Abs., 37, 4, 26 (1957).

178. Stevenson, R. E., and Grady, J. R., "Plankton and Associated Nutrients in the Waters Surrounding Three Sewer Outfalls in Southern California." Allan Hancock Foundation for Sci. Res., Univ. of Southern Calif., 49 (1956); Water Poll. Abs. (Brit.), 30, 213 (1957).

179. Stoll, L., "The Hygienic Importance of Drainage from Slaughter Houses." Ztschr. f.d.g. Hyg. u. ihre Grenzgebiete (Germany), 2, 382 (1956); Bull. Hyg., 32, 470 (1957).

180. Stommel, H., "Computation of Pollution in a Vertically Mixed Estuary." THIS JOURNAL, 25, 9, 1065 (Sept., 1953).

181. Stroud, R. H., and Seaman, E. A., "Fish Conservation Highlights of 1956." Sport Fishing Inst., Washington, D. C., 172 (1957).

182. Sullivan, M., Bartley, C. H., and Slanetz, L. W., "Numbers and Types of Enterococci and Coliforms in Feces, Water, and Sewage." Amer. Jour. Pub. Health, 47, 618 (1957).

183. Surber, E. W., "Biological Criteria for the Determination of Lake Pollution." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 164 (1957).

184. Sykes, J. E., and Lehman, B. E., "Past and Present Delaware River Shad Fishery and Considerations for its Future." Research Rept. 46, Fish and Wildlife Service, 25 (1957).

185. Tarzwell, C. M., "Water Quality Criteria for Aquatic Life." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 246 (1957).

186. Tarzwell, C. M., and Henderson, C., "Toxicity of Dieldrin to Fish." Trans. Amer. Fish Soc., 86, 245 (1957).

187. Tauson, A. O., "The Effect of Industrial Effluents on River-Bottom Fauna. II. The Effect of the Discharge of Effluents from Chemical Plants on the River-Bottom Fauna of the Kama and its Tributaries." Uchenye Zapiski Molotov. Gosudarst Univ. im. A. M. Gor'kogo (U.S.S.R.), 7, 3, 71 (1955); Chem. Abs., 51, 7620 (1957).

188. Taylor, E. W., "The Results of the Bacteriological, Chemical and Biological Examination of the London Waters for the Years 1953-1954." Metropolitan Water Bd. - Thirty-Sixth Rept. (England) 48 (1954).

189. Tsivoglou, E. C., Harwood, E. D., and Ingram, W. M., "Stream Surveys for Radioactive Waste Control." Jour. Amer. Water Wks. Assn., 49, 6, 750 (1957).

190. Tsivoglou, E. C., and Towne, W. W., "Sources and Control of Radioactive Water Pollutants." THIS JOURNAL, 29, 2, 143 (Feb., 1957).

191. Uhlmann, D., "Mass Development of Daphnia magna and Daphnia pulex Caused by Sewage." Vom Wasser (Germany), 22, 167 (1955); Water Poll. Abs. (Brit.), 30, 216 (1957).

192. Van Beneden, G., "The Effects of Sludge Discharge and Their Bottom Deposits on the Biological Equilibrium of Receiving Streams." Bull. Centre Belge Etude et Document. Eaux (Belgium), 36, 99 (1957); Pub. Health Eng. Abs., 37, 11, 17 (1957).

193. Venhataraman, R., Chari, S. T., and Sreenivasan, A., "A Hydrological Investigation of a Large-Scale Fish Mortality in a Temple Tank." Proc. Indian Acad. Sci., 44, 2, 85 (1956); Pub. Health Eng. Abs., 37, 5, 22 (1957).

194. Vinogradov, K. F., "Permissible Concentrations of Harmful Substances in Water." Khim. Prom. (U.S.S.R.), No. 6, 56 (1954); Water Poll. Abs. (Brit.), 30, 36 (1957).

195. Viswanathan, R., et al., "Infectious Hepatitis in Delhi (1955-56); A Critical Study, Epidemiology." Ind. Jour. Med. Res., 45, 1 (1957).

196. Vivier, P., "Pollution of Rivers and Lakes." Eau (France), 43, 284 (1956).

197. Wagner, H., "The Use of Turbines for Aerating and Oxygenating River Water." Voith-Forschung u. Konstruction (Germany), No. 1, 4 (1955); Water Poll. Abs. (Brit.), 30, 1, 34 (1957).

198. Waldichuk, M., "Report on Pollution Studies Conducted in Western Canada." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 188 (1957).

199. Wallen, I. E., Greer, W. C., and Lasater, R., "Toxicity to Gambusia affinis of Certain Pure Chemicals in Turbid Waters." THIS JOURNAL, 29, 6, 695 (June, 1957).

200. Warren, C. E., and Doudoroff, P., "Cooperative Research at Oregon State College in the Biological Aspects of Water Pollution." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 201 (1957).

201. Watkins, S. H., Hays, H., and Elliker, P. R., "Virucidal Activity of Hypochlorites, Quaternary Ammonium Compounds, and Iodophors Against Bacteriophage of Streptococcus cremoris." Jour. Milk and Food Tech., 20, 84 (1957); Pub. Health Eng. Abs., 37, 7, 15 (1957).

202. Weimann, R., "Natural Observation of Streams." Desinfekt. u. Gesundheitswes (Germany), 48, 65 (1956); Water Poll. Abs. (Brit.), 30, 142 (1957).

203. Weiss, C. M., and Botts, J. L., "Factors Affecting the Response of Fish to Toxic Materials." THIS JOURNAL, 29, 7, 810 (July, 1957).

204. Wiley, A. J., Lueck, B. F., Scott, R. H., and Wisniewski, T. F., "Cooperative State-Industry Stream Studies - Lower Fox River, Wisconsin." THIS JOURNAL, 29, 1, 76 (Jan., 1957).

205. Willis, A. T., "Anaerobic Bacilli in a Treated Water Supply." Jour. Appl. Bact., 20, 61 (1957).

206. Willis, A. T., "Observations on the Anaerobes Present in a City Water Supply, with Special Reference to Clostridium welchii." Jour. Appl. Bact., 20, 53 (1957).

207. Wilson, J., "Effects of Turbidity and Silt on Aquatic Life." Biol. Problems in Water Poll., Trans. Seminar Biol. Problems in Water Poll., R. A. Taft San. Eng. Center 1956, 235 (1957).

208. Wisdom, A. S., "Legal Aspects of Water Pollution." Jour. and Proc., Inst. of Sewage Purif., Part 3, 254 (1956).

209. Wlodek, S., "Effect of Tannery Waste Waters on Organisms of Surface Waters." Roczn. Zakl. Hig. Warsz. (Poland), 6, 303 (1955); Water Poll. Abs. (Brit.), 29, 358 (1956).

210. Wood, P. C., "Factors Affecting the Pollution and Self-Purification of Molluscan Shellfish." J. Cons. int. Explor. Mer. (Denmark), 22, 200 (1957); Water Poll. Abs. (Brit.), 30, 251 (1957).

211. Zimmermann, W., "Danger to Water Supplies by Benzene and Other Motor Fuels." Stadtehyg. (Germany), 6, 216 (1955); Water Poll. Abs. (Brit.), 29, 250 (1956); Pub. Health Eng. Abs., 37, 3, 25 (1957).