# Preliminary Report on the Control of Stream Pollution in Oregon

By
C. V. LANGTON
and
H. S. ROGERS

Bulletin Series, No. 1
March, 1929

Engineering Experiment Station
Oregon State Agricultural College
CORVALLIS

THE Oregon State Engineering Experiment Station was established by act of the Board of Regents of the College on May 4, 1927. It is the purpose of the Station to serve the state in a manner broadly outlined by the following policy:

(1) To stimulate and elevate engineering education by developing the research spirit in faculty and students.

(2) To serve the industries, utilities, professional engineers, public departments, and engineering teachers by making investigations of interest to them.

(3) To publish and distribute by bulletins, circulars, and technical articles in periodicals the results of such studies, surveys, tests, investigations, and researches as will be of greatest benefit to the people of Oregon, and particularly to the state's industries, utilities, and professional engineers.

To make available the results of the investigations conducted by the Station three types of publications are issued. These are:

(1) *Bulletins* covering original investigations.

(2) *Circulars* giving compilations of useful data.

(3) *Reprints* giving more general distribution to scientific papers or reports previously published elsewhere, as for example, in the proceedings of professional societies.

Single copies of bulletins are sent free on request to residents of Oregon, to libraries, and to other experiment stations exchanging publications. Additional copies, or copies to others are sent at prices covering cost of printing, as long as available. The price of this bulletin is fifteen cents.

For copies of publications or for other information address

Oregon State Engineering Experiment Station,
Corvallis, Oregon

# CONTENTS


| | Pages |
|---|---|
| I. Introduction | 5-8 |
| 1. Agencies Interested in Problem | 5 |
| 2. Past Studies | 5-6 |
| 3. Request for Preliminary Report | 6-7 |
| 4. Personnel of College Committee | 7 |
| 5. Objectives of Sanitary Surveys | 7-8 |
| 6. Determination of Conditions | 8 |
| 7. Natural Purification of Streams | 8 |
| 8. Stream Standards Not Arbitrary | 8 |
| 9. Economic Benefits | 8 |
| II. Nature of State Problems | 9-13 |
| 10. Regional Nature of Problem | 9 |
| 11. Geographical Divisions | 9 |
| 12. General Factors Considered | 9-10 |
| 13. Significance of Pollution | 10 |
| 14. Pathogenic Menace | 10 |
| 15. Relation to Water Supply | 11 |
| 16. Economics of Purification | 11-12 |
| 17. Variable Conditions | 12 |
| 18. Related Problems | 12 |
| 19. Urgency of Problem | 12 |
| 20. Initial Steps in Survey | 12-13 |
| 21. Data Available | 13 |
| 22. Willamette Valley Chosen for Survey | 13 |
| III. Recognized Standards and Practice | 13-21 |
| 23. Factors Affecting Stream Conditions | 13 |
| 24. Practical Necessity of Ultimate Disposal | 13-14 |
| 25. Effect of Climate on Available Oxygen | 14 |

26. Organic Life Index of Conditions ..... 14-15
27. Factors Affecting Fish Life ..... 15
28. Biological Standards of New York State ..... 15-16
29. Sewage Standards Not Arbitrary ..... 16
30. Broad Standards of Sewage Dilution ..... 16
31. Accepted Dilution Practice ..... 16-17
32. Oxygen Requirements of Sewage ..... 17
33. British Standards ..... 17-18
34. Physical Characteristics of Sewage Wastes ..... 18
35. American Public Health Association Guides ..... 18-19
36. Nature of Industrial Wastes ..... 19
37. Significance of Industrial Wastes in Oregon ..... 19-20
38. Outline of Complete Stream Surveys ..... 20-21

IV. Procedure Applicable to Oregon Streams ..... 21-23
39. Practice in Other States ..... 21-22
40. Approach to Municipal Waste Control ..... 22
41. Approach to Industrial Waste Control ..... 22-23
42. Agencies for Controlling Oregon Conditions ..... 23
43. Proposed Preliminary Survey and Report ..... 23

# Preliminary Report on the Control of Stream Pollution in Oregon

*By* C. V. LANGTON
*Director of Health and Physical Education*
*and*
H. S. ROGERS
*Dean of the School of Engineering and Mechanic Arts; Director of Engineering Experiment Station*

## I. INTRODUCTION

1. **Agencies interested in problem.** The prevention of stream pollution and the correction and control of pollution in Oregon are matters of great concern to all citizens. Each city dweller may be called upon to "pay the bill" for the treatment and purification of sewage and garbage wastes; some citizens have a commercial interest in fishing and the fish resources of the state; and many others are interested in the preservation of the natural beauty and recreational opportunities existing on Oregon streams. The condition of streams and stream life is more particularly a matter of concern to those who are responsible for the protection of streams, for the public health, for the water supplies, and for the waste disposals of our cities, as well as to those who must find some method for disposing of industrial wastes.

With a sense of this responsibility the Oregon State Health Department and the Oregon State Fish and Game Commissions have for several years been contemplating an approach to the problem of eliminating the pollution and contamination in our streams which are a hazard to public health and are inimical to commercial and game fishing. The League of Oregon Cities has also given consideration to the problems in order to guide and participate in legislation which might be directed toward the correction of sewage pollution in streams. It is for those who are thus particularly concerned with responsibility for conditions in the surface waters of the state that this somewhat technical bulletin is written.

2. **Past studies.** As an initial step in the study of pollution, a conference was called in Salem in September, 1926, by the

State Board of Health to sketch a general outline of the problem, organize an Anti-Stream Pollution League, and appoint a committee to make a study and report upon the steps to be taken. This committee met several times and called a meeting of the League of Oregon Cities in December for the purpose of presenting a preliminary report and advising the preparation of legislation for means of investigating stream pollution. The measures prepared, however, were not enacted.

Other agencies have also given some thought and study to the problem. In the spring of 1927 the Public Health Section of the City Club of Portland published a report upon stream pollution which set forth the sources and consequences of pollution and classified the conditions of water supply and sewage and waste disposal found in the cities of the state. The classifications were based on data compiled from reports from sixty of the cities and from the records of the State Board of Health.

The State Board of Health has continued to supervise and control the water supplies and the sewage and waste disposal of cities as it has been able to procure and use funds for this purpose and within the scope of its responsibility.

The Portland City Bacteriological Department has for two years been making studies of the conditions in the Willamette Valley as they are related to the disposal of city sewage.

All of these agencies have been anticipating the necessity of a comprehensive scientific study and a well-organized approach to the solution of the problem.

The Oregon League of Municipalities has continued its consideration of sewage disposal and has instructed its executive committee to make a study of the sewage disposal problem and report at its fall meeting.

3. **Request for preliminary report.** Various agencies of the Oregon State Agricultural College have followed the trend of public interest and responsibility, and have cooperated in a small way in the various conferences and with the State Health Department. The problem of sanitary surveys of the stream basins of the state has been discussed at various times with the State Health Department and it has been anticipated that it would be possible to place student sanitary engineers in the field during the summer vacation periods to gather data on stream conditions.

Hon. Chris. Schubel, of Oregon City, on behalf of the executive committee of the League of Municipalities, recently requested

the cooperation of the College in a study of the conditions of Oregon streams. This preliminary report is written in response to that request in order that those interested may get an understanding of the sanitary objectives of stream surveys as ordinarily performed in other states, of the general scope, approach and nature of the problems in our state, of the standards and factors used as criteria of conditions, and of a procedure applicable to Oregon streams. The report sets forth such a procedure and recommends initial steps and a program for its execution. It is written with the contemplation that preliminary waste and water surveys upon one of the stream basins of the state will be performed before the fall meeting of the League of Municipalities and will be presented at the meeting as a typical example of procedure to be followed.

4. **Personnel of College committee.** A committee of specialists on the College staff was appointed to cooperate in the preparation of this report and in the direction of future work related to the problems of stream pollution which may be carried on as a sanitary engineering project by the Engineering Experiment Station or by other College agencies. The personnel of this committee is as follows:

Professor G. V. Copson, Bacteriologist
Dr. Nathan Fasten, Biologist, Specialist in Fish Life
Dr. J. H. Hance, Geologist
Dr. C. V. Langton, Doctor of Public Health
Professor C. A. Mockmore, Municipal Engineer
Dr. F. E. Rowland, Industrial Chemist
Dean H. S. Rogers, Director of Engineering Experiment Station

All members of it have contributed to outlining the report, which was written in large part by H. S. Rogers and C. V. Langton, with sections on fish life by Nathan Fasten and on industrial wastes by F. E. Rowland.

5. **Objectives of sanitary surveys.** In general, sanitary surveys are conducted for the purpose of ascertaining the hazards to public health in a particular locality. They also include with the study of hazards to public health an economic study of the conservation of fish and aquatic life, and the cost of treating water supplies that have been contaminated by industrial wastes. The ascertaining of necessary facts concerning serious stream pollution and the possible methods of alleviating conditions are of prime importance. A well-developed program aiming at the control of

river pollution, with due regard for public health and aquatic life, a fair apportionment of the burden of control, and reasonable economy, must be founded on accurate and fundamental data.

6. **Determination of conditions.** The first objective of any survey should be a determination of the nature and extent of pollution. This will entail field work over a protracted period of time. It will be necessary to establish the fact that a problem really exists and to show its extent. This will in turn determine what steps should be taken to correct the situation. From an economic standpoint, the effect of pollution on aquatic life of streams must be determined, if state laws for protecting fish life are to be sound and enforceable.

Perhaps the most important objective in a sanitary stream survey is to remove and to prevent health hazards in water supplies and on recreational areas. There is a wide gap, however, between that which sanitarians deem advisable and that which is obtainable.

7. **Natural purification of streams.** It is a fact well-known among sanitarians that streams tend to purify themselves through certain natural phenomena, which are dilution, sedimentation, sunlight, vital concurrences, unsuitable food supply, aeration, and chemical precipitation. A determination of the activity and operation of these factors in streams is necessary in the solution of sanitary problems and must be made one of the objectives in a sanitary survey.

8. **Stream standards not arbitrary.** Objective standards of the quality of water which are applicable to streams of this state must be determined and established. Standards of quality differ depending upon the factors influencing the quality of water in each locality. Some of the factors influencing the quality of water in a stream are temperature, condition of watershed, storm flow, seasonal flow of stream, capacity for natural purification, source of public water supplies, amount and nature of industrial and sewage wastes.

9. **Economic benefits.** The gathering of information which will enable the state to anticipate and eliminate conditions inimical to aquatic and piscatorial life is of special importance in Oregon and should result in a great economic saving as it will permit future planning based on scientific data and eliminate the development of many unfavorable conditions. It is less expensive to prevent than to cure.

## II. NATURE OF STATE PROBLEMS

10. **Regional nature of problem.** The agencies for conserving the natural resources and protecting the public health of the state are usually established with jurisdiction corresponding to the political and geographical boundaries of governmental units. When a state begins to consider the problem of stream pollution, therefore, it sets up agencies with authority and responsibility coincidental with state lines. The problems of stream pollution, however, are not thus bounded or subdivided; they are problems especially pertinent to each stream or geological basin. The problems arising in the prevention or correction of the pollution of the Willamette Valley and its tributaries may be similar to those of one valley but may be quite dissimilar from those of another valley. The problems of any basin may be germane to it alone. For the purpose of a state-wide study, therefore, the work may be subdivided into districts corresponding to the stream basins or regions where similar conditions exist and which are closely related geographically.

11. **Geographical divisions.** The following subdivisions of the state are recommended as units of a state-wide survey:

a. Coast Region
b. Willamette Valley
c. Umpqua Valley
d. Rogue Valley
e. Deschutes and Hood Valleys
f. John Day Valley
g. Umatilla and Morrow Counties
h. Snake River Valley
i. Klamath River Valley
j. Lake County
k. Harney County

The Coast Region includes that territory west of the Coast Range and north of the divide between the Siuslaw and the Umpqua rivers.

Within each region the conditions are more or less uniform and the areas are of an extent to be conveniently handled as units. The arteries of communication and travel are also convenient for the making of field surveys.

12. **General factors considered.** Many factors are related to the problem of controlling stream pollution. Among these are (1) the public health as affected by municipal and domestic water supplies and public drinking places on roadside and recreational areas, (2) the economic value of the fishing industry, (3) the recreational value of the game fishing, (4) the natural beauty of the streams, (5) the legal responsibility of industrial agencies

polluting streams, (6) the responsibility of cities for pollution and the legal authorization for measures and works to prevent pollution, and (7) the responsibility of the state for the removal of health hazards and the conservation of stream life and beauty. The goals achieved in the maintainance of standards in other countries and states vary with the economic and health significance of streams and the pride in natural and undefiled conditions.

13. **Significance of pollution.** Rivers must necessarily act as sewers for the regions they drain and a certain amount of pollution is inevitable. The most significant factor of stream contamination is the danger which arises from discharge of municipal sewage into rivers which thereafter serve as a source of municipal water supply or which may be used for public bathing. The greatest danger to public health is created by sewage wastes, while on the other hand, industrial wastes are usually not a public health menace. They are important as they interfere with water purification.

The next important factor is the destruction or migration of fish life. It is in itself an index of conditions too gross for satisfactory correction by the ordinary methods of water treatment. The presence of fish and stream life, therefore, becomes an index of stream conditions. Industrial wastes are usually of most significance because of their influence on this fish and general stream life.

In this country where streams furnish the drainage for all large cities, and law inforcement for preventing pollution is not in successful operation, a danger in recreational areas to people bathing in polluted streams is created by exposure to infection which may be introduced into the stream by human wastes. The cost of maintaining a standard of water purity in streams that will not be a health menace to bathers, however, even if such a thing were possible, would be prohibitive.

14. **Pathogenic menace.** The most dangerous contamination is immediate, or that in which bacteria are transferred in a fresh and virulent form. Typhoid bacteria do not multiply in water, therefore the transfer must be made within the life cycle of the organism, which is largely dependent upon the water temperature. Partial protection may be secured by installing sewage disposal plants for upstream towns and by abolishing all overhanging privies and incidental sources of contamination. This must be enforced by sanitary inspection.

15. **Relation to water supply.** In general it may be said that no stream draining an inhabited area can be considered safe for drinking purposes without some means of purification even though the sewage flowing into the stream has been treated and reasonable precautions taken in connection with it. This of course will vary in different basins as it will also vary within the same basin, depending upon the amount and type of the industrial and sewage wastes. Much of the surface water will reach the stream without passing through sewers, as for example, storm overflows, street wash, farm wastes, and other discharges which cannot be controlled. Through these sources the health hazard is introduced into water supplies used for drinking purposes.

Water used for drinking purposes may be divided into two types, ground water and surface water. Water which passes beyond reach of vegetation, due to forces of gravity, must pass down through the soil until it reaches an impervious layer. The accumulation of this water in the ground is called ground water. This type of water is generally suitable for drinking purposes without treatment due to the fact that it usually has traveled some distance through the ground, which affects the quality of the water through physical, chemical, and biological changes.

Surface waters include rivers, creeks, large and small lakes, ponds and impounding reservoirs, all resting on the surface of the earth in contact with atmosphere. The chief source of drinking water in Oregon is of this type. While this is so, very little of the water is subjected to gross contamination and pollution, as most sources of supply come from the mountains where the catchment areas are protected and sparsely populated. Where sources can not be protected cities should have treatment works for purifying water supplies. Hence in this state, as in other states, the first open stream problem is probably one of fish preservation rather than the removal of the health hazard.

16. **Economics of purification.** Considering the matter of stream pollution as an economic engineering problem, it is cheaper to purify water taken from rivers than it is to purify sewage before it is emptied into them. The volume handled is less and the cost of purifying a million gallons of water is much less than the cost of purifying a like amount of sewage. Furthermore, at present, water can be purified more effectively and with greater certainty than can sewage. Complete purification of sewage is not attempted even in the best conducted plants, as the process

would be too elaborate, too expensive and too uncertain of results. Both methods, however, are essential, that is, a reasonable protection of our streams against contamination and also the purification of water taken from polluted streams and used for drinking purposes.

17. **Variable conditions.** The amount of contamination in a river tends to increase as the flow nears its mouth and population of the watershed increases. Often pollution increases more rapidly than the dilution of the stream and more rapidly than it can be disposed of by natural forces of purification. The character of a stream may change with the seasons. A sudden change may be produced by heavy rainfall. General changes, covering a long period of time, occur with increasing population and consequent pollution. The sanitary significance of such changes are important as they act as a measure of retrogression in quality of water and as an indication of a trend toward an incipient nuisance and a sanitary menace.

18. **Related problems.** The control of rodents and mosquitos is closely related to general sanitary problems. The mosquitos in some sections of the state, while perhaps not a health menace, are a nuisance. A well-planned survey should include a study of the reclamation or oil treating of swamps and low lands, which will tend to eliminate mosquitos. Rodents have also become a serious consideration in preventive medicine. Moreover, they frequently cause great economic loss. Among diseases spread by rodents may be included infectious jaundice, trichinosis, and plague. Rodents may harbor parasites which are pathogenic to man.

19. **Urgency of problem.** Certain factors bearing upon the urgency of studying problems within the state are as follows:

(1) The nature and value of fish life.
(2) The need for public water supplies.
(3) The relationship to recreation.
(4) The increasing density of population.
(5) The extent of trespass upon watersheds.
(6) The threat of legislation unfounded on facts and conditions.

20. **Initial steps in survey.** The initial steps necessary for the determination of conditions in any valley are to make a waste survey and a water survey for the purpose of determining (a) the nature and extent of pollution, and (b) the physical, biochemical, and bacteriological condition of the waters in the stream. After

these data have been collected it can be determined whether a special study of the effect on aquatic and fish life is necessary. These preliminary surveys may give the data necessary for correcting any unsatisfactory conditions and establishing effective control over pollution.

21. **Data available.** A certain amount of data is already available for these preliminary studies. The United States Geological Survey reports contain records of all principal streams in the state which will give data indicating the amount of dilution of sewage and industrial wastes by the minimum flow of the stream. Other records concerning the source of water supply and the manner of sewage disposal and incidental bacterial counts and biochemical oxygen determinations are available in the State Department of Public Health. The City of Portland has a two years' study upon the conditions in the Willamette river within its boundaries.

22. **Willamette Valley chosen for survey.** A survey should be undertaken to establish the advisability for action by ascertaining the conditions as outlined above. The practice, standards, and scientific data pertaining to this problem will be found in the following pages of the bulletin. Since the amount of pollution in a basin is directly proportional to the population and the magnitude of its industries, it is apparent that the Willamette Valley is probably the region in which to begin the study. The conditions in the Willamette Valley are moderated, however, by the large volume of stream flow and it does not necessarily follow, therefore, that a survey will demonstrate them to be worse than in other valleys.

## III. RECOGNIZED STANDARDS AND PRACTICE

23. **Factors affecting stream conditions.** The factors operating to affect the sanitary conditions of any stream are: first, the volume, the physical, chemical, and biological characteristics of the polluting material; second, the ability of the stream through mechanical, biological, and chemical processes to absorb and neutralize the polluting material. Each stream will vary in both of the above-mentioned points. It is impossible, therefore, to be specific concerning factors affecting stream conditions before making a field survey.

24. **Practical necessity of ultimate disposal.** The principal polluting materials are industrial and human wastes. The dis-

charge of these into streams is the only practical method of ultimate disposal in many cases and constitutes a proper and necessary use of streams, provided certain conditions are operating to prevent nuisances, to modify the health hazard, and to lessen the economic burden of purification.

Nearly all wastes, either chemical or biological, cause a reduction in the dissolved oxygen in streams. The amount of dissolved oxygen is an excellent index to the sanitary condition of a stream, and also of its ability to support plant and animal life. While both industrial and chemical wastes demand oxygen in their assimilation and in the completion of the nitrogen cycle, the industrial wastes require more oxygen than do the sewage wastes. This factor is important in a consideration of the amount and type of industrial wastes.

25. **Effect of climate on available oxygen.** The climate and temperature have a decided effect upon oxidation processes of the stream. Biological oxidation goes on more rapidly in warm weather than in cold weather. The oxygen demand is therefore greater in warm weather, and the oxygen available in natural water is less in warm water than in cold. In other words, when most oxygen is required, the streams actually contain less. The ability of water to absorb gaseous oxygen at various temperatures is shown by the following tabulation:

| Temperature F. | Maximum oxygen which can be absorbed, parts per million |
|---|---|
| 32° | 15.0 |
| 50° | 11.5 |
| 70° | 9.0 |
| 90° | 7.5 |

If a small amount of industrial waste and sewage is discharged into a large body of water, the processes of dilution, sedimentation, and natural bacterial purification may be sufficient to neutralize the polluting material provided the time element is sufficient. In the last analysis, however, the capacity of any stream to receive and oxidize wastes depends upon its oxygen resources.

26. **Organic life index of conditions.** Biologically speaking, it may be said that the organic life of a stream is a good index to its purity. When normal free-living forms, both plant and animal, are found within a body of water, it is fairly safe to conclude that conditions are favorable; on the other hand, when such forms are few in number or lacking, it is more than likely

that conditions are unfavorable. In studying pollution problems in relation to organisms, particularly fish, the method, therefore, is to discover by surveys the factors which are deleterious to the maintenance of the normal free-living organisms usually associated with a healthy stream.

27. **Factors affecting fish life.** Wisconsin, Michigan, New Jersey and New York have devoted considerable attention to the study of fish life and have discovered that, in the main, the following factors are most important:

(1) The reduction of dissolved oxygen in a stream to below fifty percent saturation. Oxygen is absolutely necessary for the life of organisms. Fish get their oxygen directly from the water, where the gas is found in the dissolved state. The entrance of sewage and other pollution into streams often tends to reduce the amount of dissolved oxygen, thereby preventing such organisms as fish from obtaining the necessary quantity. It has been estimated that when the oxygen saturation of a stream falls below twenty percent, no fish can possibly live in its waters.

(2) Some wastes, particularly those coming from chemical industries, gas plants, and mines, are especially toxic or poisonous to fish. The eggs and larvae of fish are particularly affected by such wastes carried in the waters of a stream.

(3) Plankton organisms, that is, small microscopic free-living plants and animals floating about and near the surface of a stream, are necessary for fish life and anything which interferes with the normal plankton of a stream may be said to be detrimental to the fish dwelling therein.

(4) The discharge of large quantities of sewage and other waste products forms sludge beds in streams. This not only depletes the oxygen, for this sort of pollution consists to a large extent of organic particles needing oxygen, but also tends to interfere with the spawn and spawning grounds of fish.

(5) The temperature of the water in a stream is very important for the fish life as well as the other organisms contained therein. Generally speaking, conditions are not nearly as good in warm as in cold water. Deforestation may sometimes change the temperature of a stream so as to ruin it for many of the organisms normally found dwelling therein.

28. **Biological standards of New York State.** The development of certain fungi, plants and animals have been found to be indices of pollution. The New York State Conservation Commission studied the aquatic life of streams as indicators of pollution. They have summarized their results as follows:

"Water molds and scums, particularly if of colors other than green, indicate decreasing oxygen—conditions are not favorable and may be worse down stream.

"Tubifex (sludge worms) mark approximately the limit of fish life.

"Rat-tail maggots, if abundant over the whole bed of the stream, are an almost certain indication of prohibited pollution.

"Bloodworms indicate recovery and conversion of wastes into fish food.

"Green plants, mosses, silks, and nets usually indicate good and improving conditions."

So far as is known no study of the organic life of Oregon streams has ever been made.

29. **Sewage standards not arbitrary.** It is usually not advisable to set definite standards for judging of stream sewage pollution nor have such practices found general acceptance in other states. It has been emphasized in several places in this bulletin that various factors are in operation in all cases which prohibit hard and fast rules from being promulgated. Each stream or basin, therefore, must be considered separately.

30. **Broad standards of sewage dilution.** The action of dilution, sedimentation and bacterial purification upon a small quantity of sewage is corrective. As the percentage of sewage to dilution increases, the amount of oxygen required also increases. The greater the amount of polluting material, the greater the tendency to exhaust the oxygen supply and permit a nuisance which is detrimental to fish life. A rough standard of minimum sewage dilution is one part of sewage to twenty or less parts of diluting water, which condition will set up putrefactive decompositions and create a nuisance.

31. **Accepted dilution practice.** In general, disposal of sewage by dilution may be said to be satisfactory when the following events take place:

(1) There is sedimentation of heavy particles.

(2) There is an oxidation of the organic matter into stable and inoffensive substances by bacterial activity through the dissolved oxygen in the water.

(3) There is a gradual destruction of fecal bacteria due to their introduction into an unfavorable environment and the activity of predatory protozoa.

The minimum amount of water required to dilute sewage is usually considered 2.5 to 4 cubic feet per second for the sewage

of 1,000 people. The Chicago drainage canal was designed on a basis of 3.3 cubic feet per second for 1,000 people.

The International Joint Commission on pollution of boundary waters between Canada and the United States adopted a standard of less than 500 B. Coli per 100 c.c. on a yearly average. This corresponds to a required dilution of 4 cubic feet per second per capita, a figure about 1000 times as large as that needed to prevent a nuisance.

32. **Oxygen requirements of sewage.** Strength of sewage is usually expressed in terms of oxygen absorbed from permanganate in four hours at eighty degrees Fahrenheit. Sewage on this basis may be roughly classified into three groups:

(1) Strong sewage absorbs more than 16 parts per 100,000.
(2) Normal sewage absorbs from 10-16 parts per 100,000.
(3) Weak sewage absorbs less than 10 parts per 100,000.

The amount of dissolved oxygen absorbed by a mixture of river water and sewage depends upon:

(1) The amount of dissolved oxygen taken up by the sewage.
(2) The amount of dissolved oxygen taken up by the river water.
(3) The proportion in which the two are combined or the dilution factor.

As explained elsewhere, when the amount of dissolved oxygen falls below a certain limit, putrefactive processes are set up and the ability of fish to live in the water is endangered.

A rough estimate of the amount of oxygen required per capita to satisfy the demand of sewage is estimated to be between 0.17 and 0.24 pounds per capita per day.

This country has not set up any definite standards in regard to the dilution or oxygen requirements of sewage. A few isolated instances have occurred where standards have been developed but these have not received general acceptance. One of the reasons for this is the fact that in general, the streams have not been over-taxed because the population has not grown to a saturation point in many places. On the Continent and in England, certain definite standards have been determined. These standards are lower than have received acceptance in this country.

33. **British standards.** The British Royal Commission on sewage disposal has adopted the following standard as a basis of purity:

"An effluent in order to comply with the general standard

must not contain as discharged, more than 3 parts per 100,000 of suspended matter, and with its suspended matters included must not take up at 65 degrees F. (18.3 degrees C) more than 2 parts per 100,000 of dissolved oxygen at 5 days. This general standard should be prescribed either by statute or by order of the Central Authority, and should be subject to modifications by that authority after an interval of not less than ten years.

"In fixing any special standard the dilution afforded by the stream is the chief factor to be considered. If the dilution is very low it may be necessary for the Central Authority either on their own initiative or on application by the Rivers Board, to prescribe a special stringent standard, which should also remain in force for a period of not less than ten years.

"If the dilution is very great the standard may, with the approval of the Central Authority, be relaxed or suspended altogether. Our experience leads us to think that as a general rule if the dilution, while not falling below 150 volumes, does not exceed 300, the dissolved oxygen absorption test may be omitted, and the standard for suspended solids fixed at 6 parts per 100,000. If the dilution, while not falling below 300 volumes, does not exceed 500 the standard of suspended solids may be further relaxed to 15 parts per 100,000.

"With a dilution of over 500 volumes all tests might be dispensed with and crude sewage discharged, subject to such conditions as to the provision of screens or detritus tanks as might appear necessary to the Central Authority."

These recommendations are based upon the conclusion reached by the Commission after an exhaustive study of a number of rivers in Great Britain, that signs of pollution will ordinarily be absent if 100,000 c.c. of river water take up no more than 0.4 gram of dissolved oxygen in 5 days at 65 degrees F.

34. **Physical characteristics of sewage wastes.** The physical characteristics of sewage are important as they give information regarding the state of the diluting medium. Color and odor are perhaps the most important of these physical characteristics. As an example, reddish brown, well coagulated solids are usually good, while grey solids not well aggregated are bad and generally indicate a septic condition.

35. **American Public Health Association guides.** Although we have no generally accepted standards for judging sewage pollution in this country, we have very accurate and scientific methods of determining the content of all waste material. Meth-

ods are set forth in the "Standard Method of Water Analysis" of the American Public Health Association for 1928. This also includes methods for the "Examination of Sewage, Effluents, Industrial Wastes, and Grossly Polluted Waters." These works should be made the guides of all attempts in gathering data and in the determination of standards.

A standard for judging and classifying wastes is the determination of the alkalinity or acidity of streams. Domestic sewage is generally alkaline while industrial wastes are usually acid. This is a simple standard but relatively accurate.

36. **Nature of industrial wastes.** The kinds of industrial wastes normally discharged into open streams may be broadly classified as follows:

(1) Suspended or colloidal mineral matters which increase turbidity and add to the difficulty and expense of coagulation or of filtration, as for example, coal and ore washing wastes.

(2) Dissolved mineral matter increasing the hardness or otherwise impairing the quality of the water and increasing the expense of water purification, as for example acid mine drainage and the salt water from oil wells.

(3) Vegetable and animal organic matters in solution and in suspension, which increase the color, turbidity, suspended matter and bacterial content, thereby increasing the difficulty and expense of water purification or overloading the purification plant, as for example the beet sugar refinery wastes and tannery wastes.

(4) Taste and odor-producing substances either organic or mineral in nature; for example, phenols in the wastes from gas and coke manufacturing, and sulfite liquors from paper pulp mills.

(5) Substances either organic or mineral, tending to stimulate growth and thereby increase the difficulty and expense of treatment, as for example, organic sulfur compounds in wool scouring wastes and mineralized nitrogen from oxidation or organic wastes of various kinds.

(6) Harmful bacteria, as for example the anthrax germ in tannery wastes.

(7) Poisons, as for example cyanide from cyanide process of gold extraction.

37. **Significance of industrial wastes in Oregon.** Comparatively speaking the streams of Oregon are in general free from industrial wastes. Whether certain reaches below plants are likewise free from objectional pollution can only be determined

by a survey. The presence of suspended or colloidal material from ore washing wastes as well as dissolved mineral matter is probably of a very limited nature. Vegetable wastes from canneries and organic wastes from tanneries are also small in gross amount.

The pulp and paper mills are perhaps the greatest source of industrial wastes and should be examined for evidence of any injurious effects upon the fish life of streams. There are a few small gas plants throughout the state in addition to the large plant at Portland which find it necessary to discharge their wastes into the rivers. In the operation of the large plant, however, great care is observed to prevent discharge which would be injurious to fish life or would foul ships. Other industrial wastes are small in amount and localized in extent.

38. **Outline of complete stream surveys.** The organization of a complete stream survey will depend largely upon the facts disclosed by initial investigations. Until definite information can be obtained as to the nature and extent of the problem, it will be impossible to indicate the scope. Any complete stream survey should include the collection of part or all of the following data:

(1) *General data* including physical, geological and meteorological characteristics and conditions affecting the stream should be obtained. The mineral content of a stream is dependent upon the geological formations, the organic content upon the density of population. In such data there should be included under physical characteristics, the slope of the land, flat or steep, type of soil or rock, vegetation, cover, forest, waste or farm land. Information concerning mean temperature fluctuations would be of value in the determination of certain biological and chemical changes.

(2) *Sewage and waste data* should be collected. It should indicate the location, amount and character of discharges in order to interpret chemical, biological and bacteriological data and to prescribe remedial measures. Under this division, density of population, number and kind of industries and the disposition of sewage and liquid wastes should be considered.

(3) *Stream flow data are necessary* to show the variation in conditions and the effect of dilution upon the extent and control of pollution. Maximum and minimum flow, relation of flood flow to rainfall, relation of rainfall to runoff, and the variations in flow over a period of months and years should be determined.

(4) *Chemical analyses* play an important role in stream sur-

veys. They are an excellent indication of the sanitary condition of the stream and the influence of the stream upon aquatic life. The tests perhaps of most practical value are the biochemical oxygen demand, the dissolved oxygen, and the oxygen consumed.

(5) *Biological observations* indicating the effect of pollution upon the flora and fauna of streams should be considered. Certain plant life, plankton, and animal life indicate graphically the sanitary conditions of a stream. Many times these observations will empirically establish the harm done by polluting materials as well as establish the ability of the stream to neutralize the wastes introduced into it. They are, however, principally aids.

(6) *Bacterial analyses* are from a health standpoint the final determination of the sanitary condition of a stream. They establish the relation of the stream to the dissemination of disease. By this means the distance which pollution travels in a stream and the probable danger to the health of individuals can be determined. They form the most important consideration in the determination of a source of supply for drinking purposes.

## IV. PROCEDURE APPLICABLE TO OREGON STREAMS

39. **Practice in other states.** Certain more or less general forms of organization have been developed in other states for the correction and controlling of stream pollution. The states of Ohio, Wisconsin, New York, Michigan, and North Carolina are outstanding examples of the manner in which controlling agencies can and do operate. The correction and controlling agencies in the state of Michigan are the departments of Conservation and Public Health. These act under a code of laws governing water pollution control. These laws—

(a) Make it unlawful for any one to discharge wastes into the stream that will tend to kill, injure, or stupefy fish or cause a menace to public health.

(b) Make it the duty of the Department of Conservation to guard against the pollution of the waters in the state and promote the propagation of game fish.

(c) Require the government of each city to file plans on sewer and water works and receive approval from the State Department of Health.

(d) Authorize cities to provide sanitary means for disposing of wastes and to make charter provision for establishing means of financing the construction and operation of sanitary works.

The departments of Health and Conservation established a cooperative arrangement under which the control of pollution could be jointly administered. The Department of Health supplies sanitary engineers and the service of the state chemist, as well as the laboratory and necessary equipment. The Department of Conservation supplies a man to direct stream surveys and the routine inspectors of field conditions who cooperate in the execution of their field duties with the force of the state game warden.

40. **Approach to municipal waste control.** The approach to the correction of conditions was made by establishing cooperative relationships with the polluting agencies throughout the state. For the purpose of controlling municipal disposal and wastes, the cities were organized into groups paralleling the geological basins, and conferences were called for each group, in which representatives of the departments of Health and Conservation outlined the problems and solicited the cooperation of the municipalities. Representatives of the two departments meet with the governmental body of each city at least once a year to discuss their various problems and get a report upon the progress that has been made. Almost all of the cities in the state have filed preliminary reports upon their waste disposals and are moving toward a correction of unsatisfactory conditions as fast as their financial situations will permit.

41. **Approach to industrial waste control.** For the correction of pollution by industrial wastes a different plan was followed. Here the polluting industries were organized according to their nature, and executive and technical committees were appointed for and by each industrial group. These groups have furnished funds to carry on research work for the correction of pollution resulting from the disposal of their wastes at the experiment station of Michigan State College. The industries have paid all bills incident to the employment of chemists and acquisition of equipment necessary for these researches. The results of the researches have been published from time to time in pamphlets which have been distributed to the state at large and to the industries in particular.

Neither the Health nor the Conservation departments have had sufficient resources to carry out a complete water survey of the state. They have, however, completed a waste survey which is maintained "up to date" by an annual study of conditions, each stream being studied separately with the object of establishing standards applicable to its conditions and public use. At

no time has there been disregard for the wide gap between the conditions desired and those obtainable within the cities' financial capacities. Approximately 80 percent of the municipalities called to conferences have submitted plans for sewage disposal, and another 10 percent are working upon their local problems.

42. **Agencies for controlling Oregon conditions.** Certain agencies that might undertake a preliminary survey of conditions and those which should exercise control over the sanitary conditions are already established in this state. A complete study of state conditions should ultimately be carried out under the direction of the State Board of Health and the Fish and Game Commissions. Legal measures to control conditions should be enacted. They should be of such a nature as to enable the Board to meet the wide variety of conditions which will be encountered in their enforcement. They may well be framed and recommended by the State Board of Health and the Fish Commission in cooperation with the League of Oregon Cities.

43. **Proposed preliminary survey and report.** A preliminary survey of the Willamette Valley would indicate the urgency of conditions and the probable scope of the state-wide surveys. Such a survey could be undertaken by the Engineering Experiment Station in cooperation with the State Board of Health and the Fish and Game Commissions during the coming summer. The extent of this survey will be determined by the conditions indicated in the initial observations and the data necessary for their full description. It is anticipated that this will be accomplished and the data for the period of dry weather flow will be analyzed and reported upon at the fall meeting of the League of Municipalities.