Papers Presented at the

FOURTH ANNUAL

IN-SERVICE TRAINING COURSE

FOR PUBLIC HEALTH INSPECTORS

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ADDRESS OF WELCOME

Mr. Chairman and Public Health Inspectors:

Again it is a real pleasure for me to have the opportunity to welcome you to campus.

This is the fourth time you have held your course here, and I expect this time most of you have been here before and that you now look forward to your visit here.

I think it a very wise policy to continue these kinds of training sessions - especially for persons in your field. We know that the volume of new knowledge is expanding very quickly, much of which tends to replace, outdate or at lease cause previously tried techniques to be modified.

I have just returned from a two day session, which really amounted to an argument arising out of disagreement as to what the role of the University should be in the continuing education of adults. Fortunately, our concept of our role is one that is similar to that of your committee - but there is no widespread agreement with our ideas. I was interested in knowing, however, that one of the leading men in education agrees that the College has a role in such in-service training courses as you have been holding these past three years. And I can assure you that we at O.A.C. will continue to be interested in such attempts to provide you in some small way with the opportunity to continue to study those areas of your work in which the need seems greatest.

I might mention that we are expecting to be granted University status. We do not know exactly when this will take place, nor what the new organization may be - but we hope to provide the same opportunities, and indeed perhaps greater opportunity, to continue education than even now exists.

Again, let me extend to you a sincere welcome to the campus. We hope, if you have not been here before, that you will take time to explore our facilities, that you will enjoy your stay and that you will go home feeling you have had a very worthwhile experience.
ADDRESS OF WELCOME

Mr. Chairman,
Gentlemen:

We in Public Health appreciate every sign, no matter how small, of progress in our field. One of the most apparent and progressive steps in recent years has been taken by your own Institute.

Of course I refer to this annual IN-SERVICE TRAINING COURSE for PUBLIC HEALTH INSPECTORS, which has proven so valuable to all concerned. In every profession it is absolutely necessary to refresh our knowledge and to add to it. Surely this is not more necessary than in the Public Health field.

I am particularly proud, therefore to welcome you today. May you enjoy your brief visit to Wellington County and leave feeling strengthened in your purpose and rightly proud of your profession.
It is my privilege to welcome you on behalf of the Ontario Branch, Canadian Institute of Public Health Inspectors, to our 4th Annual In-Service Training Course at the Ontario Agricultural College, Guelph. The increasing attendance each year is most encouraging, since it reveals not only a sincere desire among Public Health Inspectors to attain additional knowledge, but also the growing awareness among our employers of the need for advanced training.

Your employment in the Public Health field need not have been long term to realize the vast changes which have taken place. Diseases common a few years ago have virtually succumbed to improved standards of prevention and control. Diphtheria, Poliomyelitis and Typhoid Fever no longer arouse the terrors produced a relatively few years ago. And yet, we need only be reminded of the recent prominence of Infectious Hepatitis to realize that we must not let down our guard. In today's world, made smaller by jet travel, Smallpox, Typhoid Fever and Malaria may only be a few hours from our nearest airports.

When we who have chosen this profession realize that we are the only group trained solely for employment in the Public Health field, the importance of self-improvement in this endeavor becomes obvious. However, while attendance at these and other courses is important, we must apply the knowledge gained to assure the utmost benefit, which means bringing fresh insight to bear in the field of our regular duties.

Your Executive presently has under study, a plan submitted by an area meeting which would utilize these In-service Training Courses as a basis for higher qualifications for Public Health Inspectors. This plan, while requiring National Executive approval, could result in much more significance being attached to these already important courses. I might point out here, that proposals such as this from our areas, fulfill the purpose intended in the organization of these area meetings.

The scope of this year's program is again a credit to the efforts of Lloyd Dodgson and his committee, and to Dr. Caldwell and the staff of the College. Subjects being dealt with this year include some in which we have had little or no previous training. Air pollution control is an increasing problem, and some agencies have already undertaken extensive programs in an effort to eliminate this threat to public health. The legal aspects of public health will be discussed, and of course this is a subject we must all understand if we are to be successful in our operations.

I am certain that most of those in attendance at this course will gain considerable benefit from these and other subjects on the program, thus contributing to your success as a vital component of the public health team.
Mr. Chairman and Gentlemen,

It is a privilege and honour to be afforded the opportunity of participating in the opening ceremonies of this the fourth annual in-service training course for public health inspectors. On behalf of the Ontario Department of Health I bring greetings and extend good wishes for a successful and fruitful course. The Department continues to view with keen interest this and similar courses which are designed to assist public health workers in sharing in the developments and current thinking as expressed by those with specialized knowledge and experience in the increasing number of disciplines comprising public health. In a setting such as this one cannot fail to be impressed by the debt all of us owe to our institutions of higher learning which help so many of diverse interests to lead fuller and more useful lives for themselves and for society at large. Not the least of such institutions is exemplified through the Department of Extension Education of the Ontario Agricultural College.

The purpose of these remarks is to focus attention on the changing challenge of public health. They are directed to you in particular as representatives of a very important part of the public health team - representatives who in considerable measure create the public image of public health. The essential role of the public health inspector is in investigation, interpretation and action. Investigation requires an enquiring outlook and intelligently developed powers of observation; interpretation is predicated on a comprehensive knowledge of the scientific tools available, action stems from investigation and interpretation within the framework of public health law and good sense.

It is only by pausing and reflecting that one can appreciate what has taken place in such a short span of time. In the course of two generations man has devised on a grander scale more means for his material comfort, pleasure, well-being and destruction than in the recorded history of all preceding generations. Yet the basic needs for man's existence remain essentially the same - shelter and clothing from the elements, a continuing supply of sound nutritious food, a healthy environment, and the evolvement of a social, political and economic society in which each may develop. Man's accomplishments have been so great that dreams of approaching utopia are expressed from time to time. Yet such is not the case. Progress in human affairs results in a widening not a shrinking, of horizons of endeavour, the presenting of new challenges. At conferences such as this one becomes stimulated to hear of the most recent advances in coping with the by-products of man's progress whether it be in the area of water or air pollution, or the results of new or increased stresses on the human organism.

The record is enviable in the combat against contagious and infectious diseases known and feared through succeeding generations. It appeared that success could have no limit. The lesson to be learned from man's survival through successive pestilences was forgotten for a while - that life tends to adapt itself to adverse conditions so that the species may be perpetuated. The causative factors of infectious diseases are themselves living organisms. So it is that we learn of strains of micro-organisms resistant to accepted control measures, and of others previously considered of minor importance now looming large because of an increased virulence.
Of some interest and importance to you as public health inspectors is a large group of bacteria - the salmonellae. These have been forcefully drawn to attention during the past decade because of the rapid increase in human infections caused by members of this group - a 25 fold increase in 10 years, a 5 fold increase in the past 5 years in Ontario. Through a variety of food products for human and animal use the intestinal flora of someone in a far-off land or of a herd or flock on the next concession may give rise to intense public health investigation across a continent. This is not a far-fetched example of changing challenge and one which requires the co-operative skills of the agriculturalist, veterinarian, food and feed processor, as well as the public health team at local, provincial, national and international levels. Fundamental to effective control is the practise of sanitary principles - an art in which you profess to be skilled.

The need in public health today as in other spheres of endeavour is for increased training facilities, continuing in-service, short-term courses, and minds receptive to new concepts to meet the changing challenges. By your attention and participation in discussions each may add to the success of the course so that new lines of thought and direction of action are developed.

Thank You.
It may be germane to start by quoting from an American publication in the food area.

The article states in part as follows:

"I realize that I am talking to a group of people who are not lawyers. I also realize that I am going to talk about the functions of one division of a law department, and most of the people I am talking to neither work in a law department nor plan to work in a law department. These facts might provide a sufficient basis for many of you to decide to close your eyes and get a little rest until the next speaker arrives. Before you succumb to this thought, and it may not turn out to be a bad idea, I would like to suggest two reasons why there may be something I can say which will be of interests to you:

(1) The very good possibility that you will, some time in the future, have to work with your law department on some phase of a food legal problem.

(2) The fact that there are many ways your law department can help you and you your law department if you are only aware of how this can and should be done."

It may, as well, be considered relevant to mention that the subject of this article is not adequate in scope since "public health law" is simply a part of the whole body of our law both statute and common law.

Public health law is a part of the whole body of the law since it is enacted by the legislature or it has been authorized by the legislature under delegated legislation, and of course the canons of interpretation apply to it and in courts interpret it and in significant respects anyone may enforce it.

The subject, formulation and enactment of public health law can be approached in a simple and practical way I think by the use of an appendix to this article to give the background. Accordingly we may approach the subject directly and thereby hurry to the heart of the matter.

The appendix is attached and is intended to set out the background of the subject.

Dealing first with the formulation of public health law we may limit ourselves to provincial and municipal levels of government.

Provincially, proposals for legislation come from a variety of sources, including departmental officials, health officers and others.

Usually the proposals have the recommendation of departmental officials and are prepared in draft form in the office of the solicitor for consideration at departmental level and further, appropriate approval.

If the proposals for legislation are accepted, then a final draft is prepared and submitted to the Legislative Counsel who is an official of the Department of the Attorney-General, for final processing.
After the Bill has been processed, it is introduced and receives First Reading and thereafter Second Reading as to principle and referred to the Committee of the Whole House, and thereafter receives Third Reading and upon Royal Assent, is in full force and effect subject to the limitations set out in the Bill itself.

In order to illustrate the formulation of public health law, I think the Swimming Pool Regulations under The Public Health Act which are now of considerable interest, may well be taken as an example to illustrate not only the development of legislation, but regulations as well.

Originally the Swimming Pool provisions in The Public Health Act were enacted about twenty years ago, and were limited to the standards for construction, maintenance and operation of swimming pools. Shortly after the enactment of enabling legislation, regulations were propounded and enacted.

Several years ago a committee was established for the purpose of propounding new Swimming Pool Regulations. The Committee was made up of a number of persons including architects, engineers and representatives of groups representing groups concerned with water safety and as well, health officers were members of the Committee.

The Committee in association with officials of the Branch concerned, prepared draft regulations. However, it was found that the enabling legislation was not adequate to authorize the Lieutenant Governor in Council on appropriate recommendation to give the regulations the force of law.

It was therefore necessary to broaden the scope of the relevant legislation considerably by extending authority and make regulations covering all phases of construction, maintenance and operation of swimming pools, and as well, include safety regulations.

The Public Health Act was amended as well to authorize Boards of Health of Health Units or municipalities which do not form part of a health unit, to pass by-laws licensing swimming pools and as well make by-laws with regard to them.

Technically the new legislation, when it comes into force in about two weeks, will operate in much the same fashion as the Eating Establishment Regulations inasmuch as the Department has the power to make regulations with regard to the general principles to be established and the local authority has power to licence and make by-laws necessary to meet local conditions. When the regulations and by-laws have been enacted, it will then be the function of Boards of Health, medical officers of health and public health inspectors to administer and enforce the regulations and by-laws. In doing so they operate as an arm of government, and as such they have authority conferred upon them by the sovereign power through the relevant legislation enunciated by the sovereign power.

**SCHEDULE**

In this article,

"Act" is an act of the Provincial Legislature or Parliament;

"Bill" is a piece of legislation introduced for consideration by the Legislature or Parliament, which, when enacted, is referred to as an Act;

"By-law" This again is delegated "legislation" passed by municipalities and boards of health under authority of a provincial act such as the Municipal Act or The Public Health Act;
"Government" The authority that has the power or authority to enact laws such as the acts, regulations or by-laws or authorize the enactment thereof;

"Regulation" is delegated legislation authorized by "enabling" legislation such as the relevant provisions of The Public Health Act. A regulation has the same force and effect as an Act of the Legislature.

BACKGROUND

Legislation must be considered in the context of the world in which we live.

It is provided in effect by statute that "the law shall be considered as always speaking" (in the present tense).

This applies to The Public Health Act as well as other legislation.

It is also provided that legislation is remedial in purpose and accordingly should be so interpreted as to effect the purpose of the legislation, either by imposing an obligation or conferring a privilege.

"Velut Arbor Aeeo".

As the tree grows, so does Legislation.

GOVERNMENTS

FORMS

There are various forms of governments, which have been established or evolved in a variety of ways.

LEVELS OF GOVERNMENT IN CANADA

There are three levels of Government in Canada, namely Federal, Provincial and municipal. The jurisdiction of the Federal and Provincial legislature are prescribed by the British North America Act.

Since municipalities are "creations" of the legislature, their jurisdictions and functions are prescribed by Provincial statutes, such as The Municipal Act and The Public Health Act.

PURPOSE - FUNCTION

The purpose of all governments is to govern and usually they endeavour to do so wisely and well for the benefit of the governed. It has been stated that it is the function of governments to maintain peace within the realm and without. It has also been stated that it is the function of government to do for people what they cannot do for themselves.

In recent years of course, in many Anglo-Saxon countries, governments have embarked upon considerable social and welfare legislation which is a relatively new development.

In carrying out the function of government it has been stated by the courts for example that the legislature within the ambits of its powers (under the British North America Act), can do anything that is not naturally impossible and is accountable to no authority, either human or divine.

METHOD OF FUNCTION OF GOVERNMENTS

Governments act through "acts", "regulations" and "by-laws" which are of course enunciated by the legislative branch of government, either directly by acts or through delegated legislation such as regulations and by-laws.
BRANCHES OF GOVERNMENT

LEGISLATIVE BRANCH

The legislative branch comprises Parliament and the legislature, whose function among other things, is to legislate.

Legislatures legislate within their respective jurisdictions both geographical and otherwise.

Municipal councils in their own way legislate by by-law as well.

EXECUTIVE

There is an executive branch of Government which among other things, enacts regulations or approves regulations as the Lieutenant Governor in Council.

JUDICIARY

The judiciary interprets the law and to a degree, makes the law, and as well enforces the law.

THE CIVIL SERVICE, THE CIVIC SERVICE AND GOVERNMENT AGENCIES

Civil servants administer the law, they do not make the laws, such as acts, regulations and by-laws. It is of course contemplated that in carrying on their duties the civil service, the civic service and others engaged in administration functions should use that measure of judgment that may be required in administration.

THE DEPARTMENT OF HEALTH

CONSTITUTION

Minister of Health
Deputy Minister of Health
Directors
Supernumeraries

Under the appropriate direction, the several directors of the Department administer and where necessary enforce the legislation and regulations assigned to them.

In the field of public health, legislation is usually enforced at the municipal or local level in association with the respective director of the department concerned. In some cases where indicated, legislation is administered directly by the department, such as large areas of unorganized territory in Northern Ontario.

Supernumeraries are made up of various branches and offices who perform very few administrative functions if any. These include the accounting branches and the office of the solicitor.

FUNCTIONS

Generally speaking the functions of the Department are as follows:

1. The Public Health Act and associated legislation and regulations, including The Sanatoria for Consumptives Act, The Venereal Diseases Prevention Act and several others.

2. Mental health and associated legislation and regulations.
3. State register legislation. There are 22 professional groups associated with the Department with some 17,000 persons registered under relevant legislation.

4. The Public Hospitals Act and the Ontario Hospital Services Commission Act - This legislation is administered by the Ontario Hospital Services Commission, and accordingly there is no direct association with the Department.
John D. Anderson,
Senior Health Inspector and Prosecutor,
Department of Public Health,
City of Toronto.

PUBLIC HEALTH PROSECUTIONS

The subject I am to deal with today is one that should be of real interest to everyone employed in our field, it is not one however that all of us are constantly in close harmony with. Far too often a condition which should be dealt with by the courts is left to lie in the hope that it will fade away. I suggest to you that the enforcement of the legislation which form the tools of your trade can and should be stepped up.

The first Public Health Act in Ontario came into being in 1874, it was designed to deal primarily with the control of communicable diseases. Since the basic legislation was formed a vast amount of material has evolved. If we can imagine the trunks of two trees as being the Public Health Act and the Municipal Act then the various regulations and By-laws may be shown as the branches and leaves. Of course there are many other provincial statutes which we are required to enforce, some of them are the Pesticides Act, the Air Pollution Act, the Maternity Boarding House Act, The Sanitoria For Consumptives Act, the Industrial Safety Act 1964 which has been introduced to replace the Factory Shop and Office Building Act, and many others. Additionally, most Acts provide for the making of regulations by an appropriate minister and finally, Municipalities pass By-laws to deal with matters of a strictly local nature.

I think it is safe to say however that our basic legislation, in fact "our Bible" is the Public Health Act as amended from time to time. This Act in part provides for the appointment of Sanitary Inspectors, for the inspection of Municipalities, for the definition of nuisances, for the enforcement of orders made by the Medical Officer of Health and provides penalties for infractions there of. And speaking of nuisances (this most misunderstood word) how many of you actually sit down and study the definition of nuisance. I would like to quote it:

Section 82 - "Any condition existing in a locality that is or may become injurious or dangerous to health or that prevents or hinders or may prevent or hinder in any manner the suppression of disease shall be deemed a nuisance within the meaning of this Act."

When one then dovetails this definition with Sections 86 and 89 of the Act it would appear to and in fact does provide an all-inclusive situation which first sets out the game and then proceeds to stipulate the rules for the game.

Now you have no doubt noted from your program that this subject is actually split into three divisions, namely:

(1) assembling information
(2) laying charges
(3) courtroom procedure

As these divisions follow a natural sequence they will be discussed in like manner.
Assembling Information

There is certain basic information necessary in each and every matter handled by a department or unit. This information is normally required for records, statistics and finally court work. The best, easiest and most appropriate time to gather the necessary information is on your initial inspection. It should be quite obvious that people will be far more co-operative at this time rather than later on when you may be delivering an order to them. We advise our staff in the City of Toronto to gather their information on this initial visit with the view in mind that each occurrence is a possible future court case. Please remember you must be able to say of your own personal knowledge what the circumstances are or were and not what anyone else has given you as second hand information.

Some of the information to be gathered now will be, the correct address; eg., street and number, municipality etc. and the correct name or names of the responsible party or parties. The assessing of responsibility is one of the greatest problems encountered and yet it should not be. The Public Health Act spells out very clearly the definition of an owner and the definition of an occupier. It also spells out very clearly, in some instances definite responsibility to an owner; however, in the matter of the "nuisance" Sections, i.e., 86 and 89, an option is provided. Here is where you as an Inspector must use your common sense and your good training. These two sections as you know use the terms owner and occupier. There have been numerous Magistrates decisions handed down in this connection but a good rule of thumb is to consider both owner and occupant responsible in the event of a major nuisance, eg., an obstructed drain. For a nuisance in a multiple occupancy building with no one in charge the owner is held responsible; however, if the nuisance is of a local nature, eg., a vermin infestation in one apartment of a multiple occupancy building, then the responsibility lies with the occupier. Similar parallels may be drawn with any given set of circumstances.

Now we have the address and responsible party, what is the nuisance? Have adequate tests been conducted to actually determine the cause as well as observe the effect. For instance a proper test should be applied to determine where a drain is obstructed and also to determine what effect if any, this has on neighbouring properties.

Perhaps a few words should be said here about ownership. This may be single, joint, partnership or limited company, either incorporated or unincorporated. It is always well to remember that leads to help in establishing ownership can be obtained from neighbours, employees, assessment records, telephone directories, city directories, registry offices, the companies register at Queens Park, etc. These cannot of course be accepted as proof; you must still satisfy yourself of ownership in face to face conversation (not over the telephone).

There is one area of concern in this business of gathering information and that is the proper recording of some. While we assume that all inspectors carry note books, how many of us actually make on the spot notes in these books, or are most of us guilty of that old practice of trusting to memory and making our recordings back at the office. I should like to point out to you that a policeman makes his notes in a book at the time of the occurrence. He cannot refer to any other written report when giving evidence and indeed he cannot read his notes but refers to them only to refresh his memory. More than one Magistrate in Toronto has questioned the practice of rewriting notes onto report sheets the next day or in some instances days later. Less than two months ago a Magistrate in Toronto refused to allow an Inspector to read his report.
So it is well to remember that the gathering or assembling of information which ultimately becomes "evidence" is a subject of extreme importance. It must not be taken lightly and nothing can be taken for granted. Many times new Inspectors inform me when I question them about ownership that they know "Joe Doakes" is the owner because that was the name placed on the file by the previous Inspector. This gentlemen, is simply not acceptable.

(2) Laying Charges

So far we have discussed possible prosecutions from the nuisance viewpoint. It must be remembered that the various regulations made under the authority of the Act spell out very definite do's and dont's. Some of these require the service of a written notice, some do not. For purposes of this discussion I will stick to a "charge" arising from a nuisance.

Let us assume a complaint has been registered concerning an obstructed drain causing sewage to back up into the cellar of a rooming house. The owners occupy the ground floor and rent rooms to a number of people on the second and third floors. The Inspector calls, determines by direct question that the owners are Mr. Joe and Mrs. Mary Doakes. He also determines the validity of the complaint, is the drain in fact obstructed and is there sewage on the cellar floor. As well he notes the type of premises and occupancy. He should at this time confront the responsible parties with the facts and determine their intention. If the response is negative, his next step is to obtain a written order from the Medical Officer of Health. This order or notice should set forth the date of inspection, the nuisance as noted, the actual order to abate the nuisance and the time limit allowed for this work. This written notice must of course be signed by the Medical Officer of Health.

The order is made out in duplicate and the original should be compared with the duplicate by the Inspector to assure accuracy. The original is then taken by the Inspector and Hand Delivered to the party to whom the order is addressed, leaving the order with any other party nullifies it. Please note also there is no provision in the Public Health Act for the sending of orders by Registered Mail.

When the order is delivered it should be discussed to ensure there is no misunderstanding. The reaction of the recipient should be noted as it will be helpful in later proving wilfulness.

Following the expiration of the time set out in the order a re-inspection must be made. If it is found that the same nuisance exists, that no attempt has been made to abate the nuisance and that no reasonable excuse exists for failure to obey the order then we have grounds to consider the laying of a charge.

If it appears that a charge will succeed, that all the witnesses are available, that the permission of your Medical Officer of Health is obtained, then the charge should be laid, using form 2 as specified in Section 695 of the Criminal Code of Canada. On this form you insert your name as informant eg., Joe B. Brown, not J.B. Brown, your occupation as Health Inspector, the full name of the accused, the date of the offence, this may be a single day, or a combination of months, or it may simply be worded "within six months ending on the date hereof" and then actually spell out the charge. Using the obstructed drain again as an example it may read:
"unlawfully did, being the owners of premises known as 1234 Blank Street, City of Toronto, wilfully neglect to carry out an order lawfully served by the Medical Officer of Health, on the Defendants, pursuant to Section 89 of the Public Health Act, being revised Statutes of Ontario, 1960, Chapter 321, requiring them to repair defective drainage, contrary to Section 116, subsection 2 of the said Act."

The information is dated, signed and together with two copies of the Summons, taken to a Justice of the Peace and sworn to. Additionally a small portion of the reverse of this form provides space for the date of appearance, name of the accused and the date it was sworn to.

Accompanying form 2 or the "Information" should be an original and a duplicate of form 6 which is the Summons as specified in Sections 441 and 700 of the Criminal Code. The Summons is addressed using the same name as in on the Information, it is completed by inserting the same date of offence, an exact copy of the wording in the Information and it gives the date, time and place of the hearing, and will be dated and signed by the Justice of the Peace. (The Summons incidentally need not be sworn to). The reverse of the Summons form has space for the name of the accused and the address. We find it good policy to put our Department name and address on top of the form as well.

The Information remains in the hands of an official of the Courts and the two Summons must be passed on to the Local Police Department for service. When service has been effected, an Affidavit to this effect is endorsed on the original and it will be returned to you. Incidentally it is important to have this in Court with you should it be necessary to prove service of the Summons.

The other document you may require at this time is a Subpoena, which is form 11 as specified in Section 604 of the Criminal Code. The Subpoena is in duplicate and is addressed to your witness with name and address. It lists the name of the accused, the date of the offence but it does not spell out the entire offence, merely saying - "unlawfully did commit a breach of the Public Health Act." It instructs the witness as to the date, time and place of the trial and is dated. This form need not be sworn to and is signed by a Justice of the Peace. Upon service being effected an Affidavit of Service is sworn to by the police serving same.

Local custom will no doubt prevail when it comes to setting the date for trial, this should be worked out with your local courts administration. To allow sufficient time for service of Summons and the retaining of counsel it is suggested that 10 days forward is not an unreasonable length of time. Again however, local custom or the urgency of the situation may be an influence.

It is always good practice to have a follow-up inspection made as close as possible to the day of trial. I'm sure some of you are wondering why the wording of the charge as spelled out in the Information and Summons specifically states "so and so did wilfully neglect". An examination of Section 116 (this may be considered as the penalty section but actually it goes much further than that) subsection 2, states in part "any person who wilfully disobeys or neglects is guilty." At first glance this would seem to give two degrees of tolerance and in fact this division was used readily for a number of years until 1958 when we launched an appeal from a dismissal of a charge where we had used the "neglect" leaving off wilfully. The appeal failed and the learned Judge, who incidentally was Mr. Justice Leo Landreville, held that the word "or" did not constitute a break in the train of words.
What I am telling you gentlemen is that in any prosecution wherein you lay a charge of failure to obey an order, you must be prepared to prove "wilful Neglect."

(3) Court Room Procedure

On the date set for trial it is well to ensure that all the witnesses are available, that any exhibits are available, and that a final inspection has been made.

If court is called for 2:00 p.m. try and be seated a few minutes prior to that time, when the Magistrate enters and the command, "order, stand up" is given, everyone rises until the Magistrate is seated. The first order of business is to deal with the withdrawals, the adjournments, the pleas of guilty and the pleas of not guilty. If an adjournment is requested and it is the first appearance most Magistrates will grant at least one extension. If the plea is guilty it is quite often possible for the prosecutor to give the Court the facts from the floor with no direct evidence being given.

When the time comes for our friends the Doakes to be called the clerk of the court rises and reading from the information calls out the names. The accused may appear in person or be represented by counsel. After identifying themselves to the Court the clerk will read out the charge and say "how do you plead?" If the plea is not guilty he will say "take a seat". The prosecutor then rises and says "I submit the Public Health Act of Ontario, or the Regulations respecting -- -- -- -- -- -- or a certified copy of By-law number -- -- -- -- -- -- depending upon what authority was used for the basis of the charge. In each instance the authority must be submitted by saying the actual words. The clerk will take the act and hand it to the Magistrate, it is always a good idea to repeat for the benefit of the Court the particular section or sections you are dealing with. Turn then and say I call, Mr. - - - - - - , The Inspector then walks to the front of the Court, receives his file and takes the witness stand. He gives his name to the Court and is sworn in. The prosecutor then begins the questions: Q "What is your occupation", A "public health inspector", Q "Who are you employed by", A "Division of Food Control and Sanitation of the Department of Public Health of the City of Toronto", Q "have you been so employed since" (here it is well to pick a date preceding the beginning of the occurrence) A "Yes I have", Q "are you familiar with the premises known as 1234 Black Street in the City of Toronto", A "Yes I am", Q "describe the premises to the Court", A "it is a three storey masonry, detached multiple dwelling", Q "who are the owners of these premises", A "Mr. Joe and Mrs. Mary Doakes", Q pointing to the accused "are these the accused sitting here" A "yes they are" Q. "I understand you visited the premises during the latter part of -- -- -- -- -- A. "Yes I did" Q. "on what date" A. "the 13th of April 1964" O. "will you tell the Court please what you observed on that date in relation to this charge" A. "I called at the premises in answer to a complaint and after applying certain tests and by observation was satisfied the building drain was obstructed and that raw sewage was laying on the cellar floor," Q. "did you discuss the situation with the accused" A. "yes I did" Q. "as a result of your inspection on the 13th of April did the Medical Officer of Health issue an order to the accused" A. "yes he did" Q. "and do you have a copy of that order with you" A. "yes I have" Q. "and did you compare that with the original and found it to be a true copy" A. "I hand delivered the order to Mr. Joe Doakes at 1234 Blank Street on 14th of April 1964." O. "Would you read the order to the Court" A. - witness then slowly reads the entire order into the record - this includes the signature, Q. "When did you again return to the premises" A. "on -- -- -- -- --
(this will be the day following the expiration of the time limit from the order)

Q. "what did you find on that date" A. "I found the building drain to be obstructed and raw sewage laying on the cellar floor" Q. "did you have any conversation with the accused at this time" A. "yes, - - - - - - Q. "have you anything further to add" A. "yes I was there this morning and the drain is still obstructed and there is raw sewage on the cellar floor" Prosecutor then turns to Counsel and says "Your witness" or to the accused saying "do you want to ask the witness any questions". If there are no questions to the witness he is instructed to stand down. If you are not calling any further witnesses then simply say "that is the case for the Crown" At this time the accused may or may not take the witness stand, that is their decision to make. Following any submission the accused may wish to make, the Magistrate may ask some questions for his own clarification. Then he will decide guilt if any and assess the penalty if any.

This series of questions is pretty well standard for any given Court case. There will be minor variations to the pattern depending upon circumstance and local custom. It is not possible in the time today to delve deeply into the ramifications sectionwise of the Act.

If I may be permitted some general observations they would have to take this form:

(1) every effort should be made to abate a nuisance without recourse to the Courts.

(2) if it is necessary to go to Court, have a strong case, present it in a strong manner and press for a strong deterrent.

(3) a conviction does not always produce the abatement of a nuisance, it may be necessary to lay the charge a second time.

(4) if you are in doubt as to a person's ability to speak English and interpreter should be arranged for.

(5) be sure to keep an extra copy of the Act with you for ready reference.

I had hoped to deal with such matters as Schedule B, the various Regulations and Municipal By-laws, perhaps you will have some questions on these during the question period.

Finally may I say it has been a pleasure speaking to you today.
"PROBLEMS IN PERSONAL COMMUNICATIONS"

1. The Communication Process (1)

An analysis of personal communication problems leads us to an analysis of the nature of the communication process.

Communication between two persons is a two-way process. "A" says something to "B" and "B" responds in some way. His response need not be verbal; it may be visual. If "A" is alert, he notes the response, and bases additional communication to "B" on this response.

Perhaps it can best be shown, with the key steps in the process, diagrammatically:

```
Source --- Message --- Receiver
<table>
<thead>
<tr>
<th></th>
<th>Encode</th>
<th></th>
<th>Decode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interpret</td>
<td></td>
<td>Interpret</td>
</tr>
<tr>
<td></td>
<td>Decode</td>
<td></td>
<td>Encode</td>
</tr>
</tbody>
</table>
```

This illustrates the existence of at least 8 key steps in the communication process, and thus 8 places at which loss may occur, misunderstandings arise, and problems result.

Note that when a message is received, the receiver then becomes in fact a source for sending a return message back to the original source, who is now a receiver. Then the whole process is repeated, if communication continues.

The Communication Process (2)

The Communication process may be looked at from a different point of view. Rather than look at the steps in the process, let us look at the attributes of the main ingredients: source, message, channel, and receiver.

An analysis of these will show that certain important attributes emerge:

<table>
<thead>
<tr>
<th>Source</th>
<th>Message</th>
<th>Channel</th>
<th>Receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication skills</td>
<td>Content</td>
<td>Hearing</td>
<td>Communication skills</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Code</td>
<td>Sight</td>
<td>Knowledge</td>
</tr>
<tr>
<td>Attitudes</td>
<td>Treatment</td>
<td>Smell</td>
<td>Attitudes</td>
</tr>
<tr>
<td>Social context</td>
<td>Elements</td>
<td>Taste</td>
<td>Social context</td>
</tr>
<tr>
<td></td>
<td>Structure</td>
<td>Touch</td>
<td></td>
</tr>
</tbody>
</table>

Notice the similarity of attributes of source and receiver. (The communication skills of the latter are of a different type, of course, - reading and listening, rather than writing and speaking - but they are still communication skills). And this similarity of attributes confirms the function of the receiver as a source in the continuing nature of the communication process.

There are many dimensions of each attribute. For example, knowledge: knowledge of his own communication skills, knowledge level, attitudes, and social context; knowledge of the various attributes of the message, channel, and receiver: all these will affect the way the source communicates, and thus the effectiveness with which he communicates.

Generally speaking, communication is made more effective with the use of more than one channel, when this is possible. Thus, when you outline a complex task or operation to a person, you may just tell him about it, but in most cases it would be more effective from a communication point of view if he could see the whole operation (sight) and actually carry it out (touch).


11. "By-passing"

One of the chief causes of misunderstanding is what is known as "by-passing." This is a problem of misinterpretation: the receiver may hear the source use a certain word and then interpret it with his own particular meanings, which may not agree with the source's meanings for the word or words.

Example: Sam - I just got a French poodle for my wife.
         Joe - Wish I could work a trade like that!
When you are the receiver of a communication, and something does not "ring true" when you get it, or even if you wish only to make sure that both you and the source have the same meanings for the particular message, there are three good steps to follow:

1. Be person-minded rather than word-minded.
   Do not ask yourself, "What does that word mean?" but rather, "What does he mean by that word?"

2. Question and paraphrase.
   Ask, if you are not sure of the source's meanings. Then, to be more certain, re-state to him in your own words what you think he is trying to communicate to you.

3. Be sensitive to context.
   A word or phrase will sometimes convey a completely different intent if it is lifted out of the original message.


III. Readability

For those who communicate by writing, the matter of readability is important. By readability is meant "ease of reading." It is very difficult to predict how easily a given piece of written material (article, memorandum, letter) may be understood, but methods have been devised to predict the ease with which the written material may be read (and generally speaking, the easier it is for a piece of writing to be read, the greater the chances that it will be understood).

One of the best known methods of measuring readability is called the Fog Index. It was developed by Robert Gunning after much research on all kinds of writing (some stream of consciousness fiction and other types are outside of what we are considering here). Gunning found that two factors emerged as significant in his analysis: sentence length and word length. He devised a means whereby any person may quickly determine the Fog Index of his own writing. The method is as follows:

1. Select a 100-word sample.
2. Determine the sentence length by dividing the number of sentences in the sample into 100. Thus if your 100-word sample contains four sentences, sentence length is 25 words.
3. Determine the number of words of three syllables or more, with the following exceptions:
   a) Proper nouns (such as "Ontario Government")
   b) Combinations of simple words (such as "housekeeper")
   c) Verbs whose root form comprises two syllables, made into three by the addition of es or ed (such as "trespasses" or "created").
4. Add (2) and (3) and multiply by four, (this is a constant obtained from a regression equation, with which we are not concerned).
5. The answer is the Fog Index of the writing, and this approximates the reading difficulty of the material as related to school grade level. Thus, a Fog Index of 11.0 would indicate that the material could be read easily by someone with a Grade 11 education or higher.
Examples

1. At the earliest level of social development, play activity doubtless paralleled such animal activities as running, jumping, jostling and wrestling, fighting, eating, drinking, and sex play. A man progressed to greater competence in mastering his external environment, he also defined and organized these spontaneous activities into functions and experiences which were more complex, symbolic and expressive of his own personality as well as the personalities of other persons with whom he acted, reacted and interacted.

This meant that ever so gradually mere gratification of basic urges was superseded by activities which had more definite social structures and processes.

Average sentence length in sample ....................... \[98 \div 4 = 25\]

No. of 3-syllable or more words ......................... \[26\]

Total \[51\]

Multiply by constant \[\times 0.4\]

Product \[20.4\]

Fog Index (and grade level of difficulty) is 20.4

2. In previous centuries one of our greatest problems was the creation and production of wealth and power. In the current century one of our greatest problems is to teach the proper use of the leisure which our creation of wealth has made available to us. A brief survey of the history of civilizations appraises us of the fact that the wise use of leisure time has not only created but helped develop all the great civilizations.

Art, science, philosophy and literature have derived from the fruitful use of leisure time and have in turn given rise to new material and immaterial aspects of culture which have set in motion social changes of great moment.

Average sentence length in sample ....................... \[100 \div 4 = 25\]

No. of 3-syllable or more words ......................... \[15\]

Total \[40\]

Multiply by constant \[\times 0.4\]

Product \[16\]

Fog Index (and grade level of difficulty) is 16.

Note

1. Average sentence length should be below 20, if possible. Some sentences are unavoidably longer.

2. A few words of three syllables or more are more familiar to readers than a shorter word. Prefer the familiar word. Generally speaking, try to keep the number of three syllable words to 10 or less in a 100-word sample.
3. Thus, if average sentence length is 20 and number of words of three syllables or more is 10 in a 100-word sample, Fog Index would be as follows:

<table>
<thead>
<tr>
<th>Sentence length</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-syllable words</td>
<td>10</td>
</tr>
<tr>
<td>Constant</td>
<td>.4</td>
</tr>
<tr>
<td>Product</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Fog Index is 12.0

4. Very few people read material voluntarily which is more difficult than Grade 12 level, irrespective of amount of education beyond this level. Exceptions: High interest of material. (For example, a person will read and re-read material dealing with a possible salary re-classification if it is written even at a Grade 25 level or higher).

There is far too much information on readability to discuss here. Persons for whom writing is an important part of their communications job should consult (and if possible, purchase) the following reference:


Note: All books listed here as reference may be ordered from the Guelph Campus Co-operative, 21 College Avenue West, Guelph.
WATER QUALITY - OWRC OBJECTIVES

GENERAL

The subject "Water Quality" is wide in scope. Industrial expansion has created a large demand for good quality water, while at the same time, industry is adversely affecting the raw water quality by the discharge of waste waters. Secondly, the urban concentration of population creates a further demand for good quality water for domestic and recreational purposes. At the same time, the waste water loading from urban population creates a heavy assimilation load on adjacent receiving waters.

For the purpose of this lecture water quality will be considered in three general categories:

- Domestic Water Supplies
- Swimming, Bathing and Other Water Contact Sports
- Dispersion and Assimilation of Waste Waters.

Industry uses water for many purposes and therefore their requirements will differ greatly. At times, domestic water quality requirements will be satisfactory, however, further treatment may be necessary for special processes, and on the other hand, reduced standards may be possible for cooling water purposes.

With the advent of intensive farming practices the agricultural requirements for water quality control have increased. This phase of the subject is very special and it will not be reviewed here.

The subject water quality is wide in scope and varied requirements are set out by different authorities. One publication on water quality cites 3,827 references. It is suggested that every health department should obtain the following two references:

Drinking Water Standards - 1962
U.S. Public Health Service
Superintendent of Documents
U.S. Government Printing Office
Washington 25, D.C.

Cost - 30¢

Water Quality Criteria, Second Edition
State of California
State Water Quality Control Board
Publication No. 3-A
State Water Quality Control Board
Room 316
1227 0 Street
Sacramento, California 95814.

Other references of note are the European Standards for Drinking Water and the International Standards for Drinking Water, both published by the World Health Organization, Palais des Nations, Geneva, Switzerland.
Terminology

In evaluating a water quality the tests may be divided into the following five categories:

Physical Characteristics
Chemical Characteristics
Bacteriological Characteristics
Radiological Characteristics
Corrosion and Scaling Characteristics.

In evaluating the various characteristics the following terms may be used:

Ideals
Criteria
Standards and Objectives

"Standards" imply definite and fixed rules;
"Criteria" are a means of forming judgement; and
"Objectives" suggest desirable ends to be reached. The term
"Ideal" is new in the water quality field and presents a method of objectively evaluating a water quality.

DOMESTIC WATER SUPPLY

The use of water by human beings for drinking and other domestic purposes is considered generally to be the highest or most essential use of water. At times industry must provide further treatment and aquatic life in streams and lakes may be destroyed or inhibited by concentrations of copper or zinc that are permissible in domestic water.

The domestic water supply industry is caught between two strong trends in water quality. On the one hand, domestic and industrial customers are demanding improved water quality and greater uniformity in the water delivered at the tap. A recent convention slogan stated that the provision of safe water was achieved in the last fifty years and that for the next fifty years the objective should be to obtain a better quality water.

Drinking Water Standards (U. S. P. H. S.)

The U. S. Public Health Service Drinking Water Standards of 1962 presents limitations and objectives under three headings: bacterial, physical, and chemical characteristics.
1. **Bacterial Quality**

The minimum number of samples to be collected from the distribution system and analyzed each month are presented in a log curve. In the lower population ranges the following table can be used to approximate the requirements:

<table>
<thead>
<tr>
<th>Populations</th>
<th>Samples per month</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2,000</td>
<td>2</td>
</tr>
<tr>
<td>2,000 - 100,000</td>
<td>one per thousand</td>
</tr>
</tbody>
</table>

(See appendix Item I for U.S.P.H.S. log curve.)

The standards set out the resampling required and the number of positive samples to be allowed. Certain physical and chemical standards may be compromised but the bacterial requirements must be rigidly followed. It is also noted that the results are related to the coliform group as a whole. Recent work relating to the fecal coliform group may provide some future revisions in the standards.

2. **Physical Characteristics**

The following limiting concentrations are recommended for water in the distribution system of a water supply:

(a) Turbidity (silica scale), not to exceed five units;
(b) Colour (standard cobalt scale), not to exceed 15 units;
(c) Threshold odour number, not to exceed three.

A fourth quality which is being given new consideration is biological requirements. The term "areal standard unit" is becoming more common in considering plankton. Algae counts may in future be included in standards to assist in evaluating the physical quality of a water.

<table>
<thead>
<tr>
<th>Algae Counts per ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areal Standard Units</td>
</tr>
<tr>
<td>0-300</td>
</tr>
<tr>
<td>1,000</td>
</tr>
<tr>
<td>10,000</td>
</tr>
</tbody>
</table>

The international standards include some information indicated in the above table.
3. Chemical Characteristics

The limits for chemical elements or compounds in water are divided into mandatory requirements for certain substances and recommended criteria for others. The mandatory limits are shown in the first part of appended Item II. The non-mandatory but recommended limits for less critical substances are shown also in appendix Item III. For arsenic cyanide and fluoride the recommended limits are given in addition to the maximum permissible concentrations.

The fluoride limits vary with the annual average of maximum daily air temperatures. The annual average of maximum temperatures in various centres are as follows:

- Toronto ............ 53
- Sudbury ............ 49
- Port Arthur ........ 56
- Ottawa ............. 51
- Welland ............ 56
- Windsor ............ 57
- Chatham ............ 56

<table>
<thead>
<tr>
<th>Annual Average of Maximum Daily Air Temperatures</th>
<th>Recommended Control Limits for Fluoride in p.p.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0 - 53.7</td>
<td>Lower</td>
</tr>
<tr>
<td>53.8 - 58.3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Presence of fluoride in average concentrations greater than two times the optimum values in the table shall constitute grounds for rejection of the supply.

4. Radioactivity

Radioactivity standards are quoted for long time use and vary acceptable levels depending on background or other modes of exposure. The term picocurie which is a micro-microcurie is used and values between 3 and 10 p/c are suggested.

Comparison of Chemical Constituents in Three Standards

Appended Item III reviews the standards set out by the U.S.P.H.S. and the W.H.O. The World Health Organization considers the International Standard to be a standard for all countries. In future it is expected that the requirements will be upgraded to match improved economic and technological resources.

AWWA Water Quality Criteria

The American Water Works Committee on Water Quality Criteria have created an ideal water quality guide. See appended Item V.
The ideal water quality criteria may be used to evaluate high quality water. The committee are satisfied with the bacterial standards set out by the U.S.P.H.S. for interstate carriers but suggest that an arithmetic mean coliform density of one per litre could be used instead of one per 100 ml.

Sealing and Corrosion Characteristic are reviewed in ideal criteria and the coupon test is given as a control.

**Raw Water Standards**

The State of California Water Quality Criteria publication presents a table which reviews raw water quality in relation to the treatment required. Biochemical Oxygen Demand and Dissolved Oxygen are two new criteria presented in the table. See appendix Item V.

**SWIMMING AND BATHING WATERS**

To be acceptable to the public and the regulatory authorities, waters that are used for swimming and bathing must conform to three general conditions:

(a) they must be esthetically enjoyable;

(b) they must contain no substances that are toxic upon ingestion or irritating to the skin; and

(c) they must be reasonably free from pathogenic organisms.

Stream standards seldom attempt to define the first two conditions but occasionally limits are set for temperature, pH, colour, and turbidity. The third condition given above, that swimming and bathing waters be reasonably free from pathogenic organisms, has been subject to strict and definite bacterial standards in many states and regions. It is agreed by most investigators that the bacterial quality of water for bathing need not be as high as that for drinking, but that natural bathing water should be maintained reasonably free of bacteria of known sewage origin. Present knowledge and technical procedures are not sufficient to permit the development of precise quantitative standards to distinguish between bathing beaches that are safe and those that are not safe. Refer to appended Item VI for a review of the requirements of various state and other agencies.

The Ontario Department of Health in Bulletin No. 103, Health Officer Information Exchange, provides the following guide:

"On a bathing beach the coliforms should not exceed 1,000 per 100 ml but up to 2,400 is permissible provided that there is no evidence of increasing pollution, the sanitary survey of the beach area is satisfactory and there is no previous significant epidemiology."

It is noted that only the U.S. Army swimming standard uses the E. coli count as a guide. Other guides use the term MPN and the Ontario Department of Health does not present a designation. The term membrane filter count may be substituted for the MPN designation. As eye, ear, nose, and throat ailments may be expected from bathing viral and new bacterial standards may be developed in future.
Surface water quality requirements vary greatly. The state of New York has a comprehensive classification programme for surface and ground waters. In this state each surface water is given a classification in one of seven classes. In each class an evaluation or requirement is presented under some or all of the following headings:

1. Floating solids; settleable solids; oil; sludge deposits; taste or odour producing substances.
2. Sewage or wastes effluents.
3. pH
4. Dissolved oxygen.
5. Toxic waste, deleterious substances, coloured or other wastes or heated liquids.
6. Phenolic compounds.

Of the seven classes the highest two, classes AA and A, are considered satisfactory for potable or domestic water uses.

In Ontario basic water quality objectives for all waters in the province are as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Day B. O. D.</td>
<td>not greater than 4 p. p. m.</td>
</tr>
<tr>
<td>MF coliform count</td>
<td>not greater than 2,400 coliforms per 100 ml.</td>
</tr>
<tr>
<td>phenol average</td>
<td>2 p. p. b.</td>
</tr>
<tr>
<td>phenol maximum</td>
<td>5 p. p. b.</td>
</tr>
<tr>
<td>pH</td>
<td>6.7 - 8.5</td>
</tr>
<tr>
<td>Iron</td>
<td>not greater than 0.3 p. p. m.</td>
</tr>
</tbody>
</table>

Adequate protection for these waters, except in certain specific instances influenced by local conditions, should be provided if the following waste discharge concentrations are obtained.

<table>
<thead>
<tr>
<th>Item</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 day B. O. D.</td>
<td>not greater than 15 p. p. m.</td>
</tr>
<tr>
<td>suspended solids</td>
<td>not greater than 15 p. p. m.</td>
</tr>
<tr>
<td>phenol</td>
<td>not greater than 20 p. p. m.</td>
</tr>
<tr>
<td>pH</td>
<td>5.5 to 10.6</td>
</tr>
<tr>
<td>iron</td>
<td>not greater than 17 p. p. m.</td>
</tr>
<tr>
<td>oil</td>
<td>not greater than 15 p. p. m.</td>
</tr>
</tbody>
</table>
Each body of water will differ in ability to assimilate waste waters. Comprehensive studies are performed to determine the capacity of a receiving water to assimilate wastes. In making such studies the effect of an existing waste load on a stream is measured to obtain the stream characteristics. From the calculated stream factors the effects of other or future loadings are calculated.

In considering a domestic waste water the assimilation consists of the biological degradation of chemical and organic material. In this process oxygen is obtained from stream reserves, algae, and natural aeration to oxidize the material. At the same time sufficient oxygen must remain to support the normal uses of the water and prevent anaerobic or septic conditions.

When extensive stream studies are not possible a dilution factor may be calculated using the B.O.D. of the waste water and the minimum flows in the river as guides. In making this type of calculation the self purification of the stream is not considered and an acceptable B.O.D. level in the receiving water must be assumed. Toxic chemicals, colour, and temperature evaluations are also possible with no consideration being given to assimilation.
Appendix Item II

CHEMICAL SUBSTANCES IN USPHS DRINKING WATER STANDARDS OF 1962

<table>
<thead>
<tr>
<th>Substance</th>
<th>Concentrations in mg/l 1962</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Maximum permissible concentrations:</strong></td>
<td></td>
</tr>
<tr>
<td>Arsenic**</td>
<td>0.05</td>
</tr>
<tr>
<td>Barium</td>
<td>1.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.01</td>
</tr>
<tr>
<td>Chromium (hexavalent)</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>*</td>
</tr>
<tr>
<td>Cyanide**</td>
<td>0.2</td>
</tr>
<tr>
<td>Fluoride**</td>
<td>1.6-3.4#</td>
</tr>
<tr>
<td>Lead</td>
<td>0.05</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.01</td>
</tr>
<tr>
<td>Silver</td>
<td>0.05</td>
</tr>
<tr>
<td>Zinc</td>
<td>*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>B. Recommended limiting concentrations</strong> (provided that other more suitable supplies are or can be made available):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkyl benzene sulfonates</td>
</tr>
<tr>
<td>Arsenic**</td>
</tr>
<tr>
<td>Carbon chloroform extract</td>
</tr>
<tr>
<td>Chloride</td>
</tr>
<tr>
<td>Copper</td>
</tr>
<tr>
<td>Cyanide**</td>
</tr>
<tr>
<td>Fluoride**</td>
</tr>
<tr>
<td>Iron</td>
</tr>
<tr>
<td>Manganese</td>
</tr>
<tr>
<td>Nitrate, as NO₃</td>
</tr>
<tr>
<td>Phenolic compounds, as phenol</td>
</tr>
<tr>
<td>Sulfate</td>
</tr>
<tr>
<td>Total dissolved solids</td>
</tr>
<tr>
<td>Zinc</td>
</tr>
</tbody>
</table>

* Maximum permissible concentrations were replaced by recommended limits after the 1925 standards.

** These substances have both recommended limits and maximum permissible concentrations.

# Recommended limits and maximum permissible concentrations for fluoride vary with the annual average of maximum daily air temperature, from the lowest concentrations at 79.3-90.5°F to the highest at 50.0-53.7°F.
## Appendix Item III

**COMPARISON OF CHEMICAL CONSTITUENTS IN THE DRINKING WATER STANDARDS OF THE WORLD HEALTH ORGANIZATION AND THE U. S. PUBLIC HEALTH SERVICE**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Permissible Limit</td>
<td>Excessive Limit</td>
<td>Maximum Allowable</td>
</tr>
<tr>
<td>Alkyl Benzene Sulfonate</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Ammonia (NH₄)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Arsenic</td>
<td>--</td>
<td>--</td>
<td>0.2</td>
</tr>
<tr>
<td>Barium</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Cadmium</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Calcium</td>
<td>75</td>
<td>200</td>
<td>--</td>
</tr>
<tr>
<td>Carbon Chloroform Extract</td>
<td>200</td>
<td>600</td>
<td>350</td>
</tr>
<tr>
<td>Chloride</td>
<td>1.5</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Chromium (Hexavalent)</td>
<td>--</td>
<td>--</td>
<td>0.05</td>
</tr>
<tr>
<td>Copper</td>
<td>1.0</td>
<td>1.5</td>
<td>--</td>
</tr>
<tr>
<td>Cyanide</td>
<td>--</td>
<td>--</td>
<td>0.01</td>
</tr>
<tr>
<td>Fluoride</td>
<td>--</td>
<td>--</td>
<td>1.5</td>
</tr>
<tr>
<td>Iron</td>
<td>0.3</td>
<td>1.0</td>
<td>--</td>
</tr>
<tr>
<td>Lead</td>
<td>--</td>
<td>0.1</td>
<td>--</td>
</tr>
<tr>
<td>Magnesium</td>
<td>5.0</td>
<td>150</td>
<td>--</td>
</tr>
<tr>
<td>Magnesium + Sodium Sulfate</td>
<td>500</td>
<td>1000</td>
<td>--</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.1</td>
<td>0.5</td>
<td>--</td>
</tr>
<tr>
<td>Nitrate (AS NO₃)</td>
<td>--</td>
<td>--</td>
<td>50</td>
</tr>
<tr>
<td>Oxygen, Dissolved (Minimum)</td>
<td>--</td>
<td>--</td>
<td>5.0</td>
</tr>
<tr>
<td>Phenolic Compounds (As Phenols)</td>
<td>0.001</td>
<td>0.002</td>
<td>--</td>
</tr>
<tr>
<td>Selenium</td>
<td>--</td>
<td>--</td>
<td>0.05</td>
</tr>
<tr>
<td>Silver</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Sulfate</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Total Solids</td>
<td>500</td>
<td>1500</td>
<td>--</td>
</tr>
<tr>
<td>Zinc</td>
<td>5.0</td>
<td>15</td>
<td>--</td>
</tr>
</tbody>
</table>

* After 16 Hours Contact With New Pipes; But Water Entering a Distribution System Should Have Less Than 0.05 MG/L of Copper.

** If There Are 250 MG/L of Sulfate Present, Magnesium Should Not Exceed 30 MG/L.

# Recommended Limits and Maximum Allowable Concentrations Vary Inversely With Mean Annual Temperature.
# APPENDIX ITEM IV
## IDEAL QUALITY WATER - CHARACTERISTICS AND CONCENTRATIONS*

<table>
<thead>
<tr>
<th>Physical Characteristics</th>
<th>Max. in Ideal Water</th>
<th>Chemical Characteristics—Nontoxic</th>
<th>Max. in Ideal Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>Less than 0.1 unit</td>
<td>Aluminum (Al)</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>0.1</td>
<td>Iron (Fe)</td>
<td>0.05</td>
</tr>
<tr>
<td>Nonfilterable residue</td>
<td>none</td>
<td>Manganese (Mn)</td>
<td>0.01</td>
</tr>
<tr>
<td>Macroscopic and nuisance</td>
<td>3 units</td>
<td>Copper (Cu)</td>
<td>0.2</td>
</tr>
<tr>
<td>organisms</td>
<td>no change on</td>
<td>Zinc (Zn)</td>
<td>1.0</td>
</tr>
<tr>
<td>Color (true)</td>
<td>carbon contact</td>
<td>Nitrate—inorganic (N)</td>
<td>5.0</td>
</tr>
<tr>
<td>Odor</td>
<td>none</td>
<td>Filtrable residue</td>
<td>200.0</td>
</tr>
<tr>
<td>Taste</td>
<td></td>
<td>Phenolic compounds</td>
<td>0.0005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(as phenol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chloroform soluble from</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>carbon adsorption</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol soluble from</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>carbon adsorption</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ABS</td>
<td>0.20</td>
</tr>
<tr>
<td>Temp—°F†</td>
<td></td>
<td>Corrosion &amp; Scaling</td>
<td></td>
</tr>
<tr>
<td>50.0–53.7</td>
<td>1.2</td>
<td>Characteristics</td>
<td></td>
</tr>
<tr>
<td>53.8–58.3</td>
<td>1.1</td>
<td>Hardness (as CaCO₃)</td>
<td>80.0</td>
</tr>
<tr>
<td>58.4–63.8</td>
<td>1.0</td>
<td>Alkalinity (as CaCO₃)</td>
<td>not more than 1 ppm change§</td>
</tr>
<tr>
<td>63.9–70.6</td>
<td>0.9</td>
<td>Coupon tests</td>
<td>3-month tests</td>
</tr>
<tr>
<td>70.7–79.2</td>
<td>0.8</td>
<td>Bacteriological</td>
<td>Max. in Ideal Water</td>
</tr>
<tr>
<td>79.3–90.5</td>
<td>0.7</td>
<td>Coliform—multitube fer-</td>
<td>1 per liter**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mentation technique#</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coliform—membrane filter technique</td>
<td>1 per liter**</td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>0.01</td>
<td>Radiological</td>
<td>Max. in Ideal Water</td>
</tr>
<tr>
<td>Cyanide (CN)</td>
<td>0.01</td>
<td>Gross beta activity</td>
<td>100 pc/l</td>
</tr>
<tr>
<td>Silver (Ag)</td>
<td>0.02</td>
<td>Radium (Ra²²⁶)</td>
<td>3 pc/l</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>0.01</td>
<td>Strontium (Sr⁹⁰)</td>
<td>5 pc/l</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chromium (Cr⁺⁶)</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total organic phosphorus</td>
<td>none†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>or chlorinated hydrocarbon insecticides</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* All results in ppm unless otherwise stated.
† Five-year average of maximum daily air temperature.
‡ No appreciable effect on test fish.
§ For decrease or increase in the distribution system also in 12 hr at 130°F in a closed plastic bottle, followed by filtration.
|| Incrustation rate on stainless steel, not to exceed 0.01 mg/sq cm; loss by corrosion of galvanized iron, not to exceed 5.00 mg/sq cm.
# Completed test or confirmed in accordance with allowed alternate in Standard Methods.
** Standard portions of either 10 or 100 ml.
Appendix Item V

RANGES OF PROMULGATED STANDARDS FOR RAW WATER SOURCES OF DOMESTIC WATER SUPPLY

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Excellent Source of Water Supply, Requiring Disinfection Only, as Treatment</th>
<th>Good Source of Water Supply, Requiring Usual Treatment Such As Filtration &amp; Disinfection</th>
<th>Poor Source of Water Supply Requiring Special or Auxiliary Treatment and Disinfection</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD (5 Day) MG/L</td>
<td>Monthly Average: 0.75-1.5</td>
<td>1.5-2.5</td>
<td>Over 2.5</td>
</tr>
<tr>
<td></td>
<td>Maximum Day, Or Sample: 1.0 - 3.0</td>
<td>3.0 - 4.0</td>
<td>Over 4.0</td>
</tr>
<tr>
<td>Coliform MPN Per 100 ML</td>
<td>Monthly Average: 50-100</td>
<td>50-5,000</td>
<td>Over 5,000</td>
</tr>
<tr>
<td></td>
<td>Maximum Day, Or Sample: Less Than 5% Over 100</td>
<td>Less Than 20% Over 5,000</td>
<td>Less Than 5% Over 20,000</td>
</tr>
<tr>
<td>Dissolved Oxygen MG/L Average</td>
<td>4.0 - 7.5</td>
<td>4.0 - 6.5</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>% Saturation: 75% Or Better</td>
<td>60% Or Better</td>
<td>--</td>
</tr>
<tr>
<td>PH Average</td>
<td>6.0 - 8.5</td>
<td>5.0 - 9.0</td>
<td>3.8 - 10.5</td>
</tr>
<tr>
<td>Chlorides, Max. MG/L</td>
<td>50 Or Less</td>
<td>50-250</td>
<td>Over 250</td>
</tr>
<tr>
<td>Fluorides, MG/L</td>
<td>Less Than 1.5</td>
<td>1.5 - 3.0</td>
<td>Over 3.0</td>
</tr>
<tr>
<td>Phenolic Compounds, Max. MG/L</td>
<td>None</td>
<td>0.005</td>
<td>Over 0.005</td>
</tr>
<tr>
<td>Colour, Units</td>
<td>0 - 20</td>
<td>20 - 150</td>
<td>Over 150</td>
</tr>
<tr>
<td>Turbidity, Units</td>
<td>0 - 10</td>
<td>10 - 250</td>
<td>Over 250</td>
</tr>
</tbody>
</table>
## Appendix Item VI

### BATHING BEACH WATER QUALITY STANDARDS

<table>
<thead>
<tr>
<th>Authority</th>
<th>Bathing Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>APHA Joint Committee</td>
<td>Average MPN coliform bacteria per 100 ml not to exceed 1,000, but maximum not to exceed 2,400.</td>
</tr>
<tr>
<td>California</td>
<td>The average MPN coliform bacteria not to exceed 1,000 bacteria per 100 ml with not more than 20 percent samples over 100.</td>
</tr>
<tr>
<td>Great Lakes and Upper</td>
<td>Coliform density not to exceed 1,000 per 100 ml. (No fresh sewage pollution in proximity.)</td>
</tr>
<tr>
<td>Mississippi River Boards</td>
<td>The average MPN coliform bacteria not to exceed 1,000 bacteria per 100 ml.</td>
</tr>
<tr>
<td>Indiana</td>
<td>Average MPN coliform bacteria not to exceed 1,000 per 100 ml.</td>
</tr>
<tr>
<td>New York City</td>
<td>Average MPN coliform organisms not to exceed 2,400 per 100 ml.</td>
</tr>
<tr>
<td>New York State</td>
<td>Average MPN coliform organisms not to exceed 2,400 per 100 ml. in series of ten or more.</td>
</tr>
<tr>
<td>Ohio River Committee</td>
<td>The average MPN coliform bacteria not to exceed 100 with a maximum of 1,000 bacteria per 100 ml.</td>
</tr>
<tr>
<td>Oregon</td>
<td>MPN not greater than 240 per 100 ml.</td>
</tr>
<tr>
<td>Potomac River Commission</td>
<td>Monthly average of 50 to 500 with a maximum not greater than 1,000 MPN coliform bacteria per 100 ml.</td>
</tr>
<tr>
<td>TB Med. 163, Sanitary</td>
<td>Class B (fair), average E. coli per 100 ml 51 to 500. Class C (poor), average E. coli per 100 ml 501 to 1,000.</td>
</tr>
<tr>
<td>Control of Army Swimming</td>
<td>Geometric average not to exceed MPN 500 coliform bacteria per 100 ml.</td>
</tr>
<tr>
<td>Pools &amp; Swimming Areas (May 1945)</td>
<td></td>
</tr>
<tr>
<td>Tennessee Valley Authority</td>
<td>Geometric average not to exceed MPN 500 coliform bacteria per 100 ml.</td>
</tr>
<tr>
<td>Washington State</td>
<td>Not more than 20 percent samples MPN in excess 240 per 100 ml.</td>
</tr>
<tr>
<td>West Virginia State Water Commission</td>
<td>The average MPN of samples collected during a month not to exceed 1,000 coliform bacteria per 100 ml.</td>
</tr>
</tbody>
</table>

**NOTE:** The sanitary survey, collection of representative samples, and their proper interpretation are of paramount importance.
Aquatic Nuisances and Their Control

The control of troublesome plant and animal life in water by chemical means is a field of endeavour that has received somewhat less attention and development here in Canada than the control of pest plants and insects in the terrestrial environment. This is, of course, to be expected, since increasing the production and quality of foodstuffs on the land is a matter of national and even international importance and, I might add, an economic necessity to the basic producer, while most of the problems associated with over-abundant aquatic fauna and flora can at best be considered as nuisances to varying degrees. The latter might not be true, except that we are blessed in this country in not having endemic diseases transmitted by insects with vulnerable aquatic life stages, and I cite as examples the mosquitoes that are vectors for malaria and yellow fever in tropical regions of the world.

You see, then, that the term I use in presenting this topic, i.e. "Aquatic Nuisances", pertains to any form of plant or animal life that either lives in or partially in water, or spends a portion of its life span in water, and which interferes with man's optimum enjoyment of the natural resources at his disposal (in his own estimation). Lest I have created the impression that I will be talking only of chemical methods of controlling aquatic pests, might I hasten to add that other measures have been attempted and will receive some attention also.

Types of Aquatic Nuisances and Their Significance

In Ontario, interest has been shown and effort has been expended in controlling the following aquatic nuisances: algae; submergent and emergent aquatic vegetation; undesirable, or "coarse" fish as they are often called, a category that has included on different occasions fish such as perch, suckers, carp, bullheads and assorted species of chub and other minnows; black flies; mosquitoes; leeches; and finally, snails, where suitable species have served as intermediate hosts for minute free-swimming parasites that cause swimmer's itch, a temporary rash acquired by bathers in lakes where the parasite has become established. Specifically, why are these plants and animals considered to be nuisances? In some cases, as for black flies and mosquitoes, the answer is perfectly obvious. They bite people! On the other hand, you may be less familiar with the importance of microscopic species of algae that can cause unpleasant tastes and odours in municipal water supplies and that can raise the cost of treating water by interfering with the efficiency of filtration. To elaborate, I can cite as an example the situation that developed at the City of Belleville last month. The water supply for this city is obtained from the highly productive Bay of Quinte that consistently produces higher algae populations than are experienced elsewhere in the province. A flagellated form of colonial algae, called Synura, developed in high numbers and caused the treated water to be quite malodorous and distasteful to drink, exhibiting a flavour that varied from cucumber-like to fishy throughout the period of investigation. Remedial measures were attempted on both an experimental and plant scale. A specialized chlorination procedure was demonstrated to provide a palatable water and was adopted to counteract the problem.
The worst feature of a situation of this nature is that it shakes the faith of the consumer in the purity of the supply and he may turn to a source of water that is good to the taste but that may be bacteriologically unsafe.

A problem of an entirely different nature is caused by a form of filamentous algae, called Cladophora, that grows abundantly to a depth of approximately ten feet in areas of Lake Erie and Lake Ontario where a rocky type of bottom is present. It creates foul odours along beaches and residential shoreline areas where it decomposes after being piled ashore following periods of rough weather. This same algae, and related filamentous forms, develop abundantly in numerous farm ponds in Southern Ontario that are highly valued for their usefulness in providing water for irrigation and stock watering, and for their aesthetic and recreational values. These algae are unsightly, they may clog pumps, interfere with fishing and cause one to forget about taking a dip on a hot summer day! Higher aquatic plants, possessing true stems and leaves, may interfere with boating, fishing, water skiing, and during certain winter seasons, winterkills of fish may result from oxygen depletion in the water caused by the decomposition of large masses of submerged vegetation. However, to keep this discourse in proper perspective, I would like to stress that algae and higher aquatic plants are not all bad! Tiny species of algae are the basis of all life in water since they nourish larger forms. Algae and aquatic vegetation maintain an oxygen balance essential to fish life and provide a suitable environment for the production of invertebrate organisms that serve as food for fish. They contribute to keeping water temperatures at the low levels essential to certain species of fish and provide shade and protection for young game fish and forage fish species. Finally, numerous aquatic plants are utilized by waterfowl both for food and protection.

Regulating the Use of Chemicals in Water

Recognizing the legitimate interest in, and need for, the control of aquatic plants and other organisms creating troublesome conditions, the Ontario Water Resources Commission took action to institute legislation that would permit chemical control measures and yet safeguard water quality and the natural inhabitants of our lakes and streams. The legislation provides for a permit system that makes it illegal for any person to apply a substance to water for the purpose of killing or affecting any form of life in water, without the authority of a permit. Provisions in the Act were made for penalties up to $500.00 and for regulations which would permit exemptions. Two exemptions were subsequently established - one that exempted approved chemicals for controlling emergent plants in drainage ditches and another that exempted wholly enclosed private ponds having no outflow. An administrative procedure had to be devised which would be suitable considering the large area of the province, and it was recognized that the possible effects of the chemicals on fish and wildlife populations would be an important and continuing consideration. It followed somewhat naturally that an administrative system developed in full co-operation with the Department of Lands and Forests, which has a well-organized province-wide field organization and with a Fish and Wildlife Branch directly responsible for managing our fish and wildlife resources. Forms and procedures were established for handling applications for permits, which are reviewed both by the Commission and the appropriate District office of the Department of Lands and Forests. Application forms are available from either agency and must be forwarded in duplicate to the Commission. The application form is designed to indicate whether the individual is capable of making all the calculations necessary to use the chemical properly and certifies that he has informed and secured the approval of neighbouring residents for the control operation.
Information is required concerning water intakes, bathing areas, other water uses and the physical characteristics of the area to be treated. When permits are issued, such terms and conditions as are deemed to be necessary may be imposed, and treatments are often supervised by Conservation Officers or a representative of the Commission.

With regard to chemicals, it soon became apparent that the technical nomenclature, along with numerous brand names and the quantity and variety of technical data available, was a study in itself. Studies of our own had to be undertaken because the literature was incomplete on such important matters as fish toxicity, chemical stability and taste and odour thresholds of various products in water. A good deal of time is spent continuously in keeping abreast of new products and new facts related to established products.

Methods of Control and the Significance of Using Aquatic Pesticides

Control of Algae

Various methods of controlling algae have evolved and the most suitable method of control depends on the problem the algae are creating.

In the water treatment field, where high algae populations consistently interfere with the efficiency of filtration or produce tastes and odours in water supplies, the algae may be removed by micro-strainers. Micro-strainers are rotary screens and the raw water is fed to the inside and flows out through the screen material. The rotary drum is about three-quarters immersed and as it turns around, a jet of water played on the surface of the screen knocks down the accumulated solids into a hopper, which are carried to waste. One disadvantage of a micro-strainer installation is the somewhat high cost involved. Copper sulphate may be applied at a concentration of 0.5 ppm to control algae in pre-treatment reservoirs or lakes used as sources of water supply. However, the reservoir must have sufficient capacity to leave an untreated "buffer zone" between the intake and the treated area, to allow for the disappearance of distasteful decomposition products associated with decaying algae. Repeated treatments may be used in reservoirs to keep algae populations under control and there is no hazard to consumers if this chemical is used properly.

Filamentous algae or "pond scum" in farm ponds may be controlled by copper sulphate applied at a concentration of 1 ppm. This concentration will not affect fish or other aquatic life in ponds with moderate to high alkalinity, as long as a uniform distribution of the chemical is achieved. The algae, Chara, which resemble the more advanced vascular plants, is very common in ponds in Southern Ontario and is somewhat more resistant to copper sulphate. A concentration of 1.5 ppm should be applied as a spray using a weed sprayer, or copper sulphate may be put into a porous bag and dragged behind a boat. The chemical is poisonous and should be kept away from the eyes, nose and mouth. Pets, cattle and swimmers should be kept away from treated ponds for at least 12 hours.

The Commission has undertaken a great deal of work in attempting to find a suitable means of controlling Cladophora, the algae which causes a tremendous odour problem along Lake Erie and Lake Ontario wherever it comes ashore in large quantities and decomposes. These odours and unsightly conditions are most serious in areas of heavy recreational utilization. Copper sulphate is not significantly effective in controlling Cladophora. Experimental studies have shown that two of the newer algicides control Cladophora quite well, but a complete program of treatment for all of the areas of growth is unrealistic because of the cost involved. Preliminary studies have been undertaken...
to develop suitable mechanical means of removing the algae, both in the water where it grows, and on the shoreline areas where it accumulates. This work will continue during the coming summer period. Other studies are directed towards an investigation of the factors that promote the growth of Cladophora and much has already been learned in this regard.

Control of Emergent and Submergent Aquatic Vegetation

The more advanced leafy and vascular types of aquatic vegetation grow profusely in farm ponds and shallower lakes throughout Southern Ontario. All plants require sunshine and nutrients. Light penetrates to the bottom of shallow bodies of water, and when the lake or pond is situated in an area of fertile soils so that drainage provides essential plant nutrients, growths of aquatic plants or algae may be expected. The problem is compounded by the use of agricultural fertilizers and enriching discharges from sanitary and certain industrial waste treatment facilities. Treatment may well prevent what we normally consider to be pollution in the form of offensive oxygen-consuming solids and toxic materials, but usually does not remove nutrient substances such as nitrogen and phosphorous which tend to promote plant growths. Prime examples of waters which are highly productive are the lakes in the Kawartha District, Rondeau Bay and the Bay of Quinte.

Aquatic plants may be controlled either mechanically or chemically. Mechanical methods of control include simple raking, dredging to increase depth, dragging a pipe covered with barbed wire, use of a floating sickle-bar, and power-driven underwater mowers. The major drawback associated with these methods is the expense of the labour involved. Spreading of weeds may be promoted with mechanical methods and drifting accumulations of weeds may present a problem. A new concept of control that we intend to investigate this summer involves use of a opaque surface film of black plastic to exclude light and maintain weed-free swimming areas in this fashion.

Time does not permit a thorough review of all the herbicides and methods of application that are employed in controlling aquatic vegetation by chemical means. This information is available from the Commission in mimeographed form and in a booklet entitled "Aquatic Plant and Algae Control". Briefly, dalapon, amitrol, 2,4-D, paraquat, and silvex are the chemicals which have shown the most promise in controlling emergent vegetation. The potassium salt of silvex and endothal are most widely used in Ontario in treating submergent species. Sodium arsenite is highly effective in controlling submergent vegetation but its use is not permitted because of its toxic nature and the fact that arsenic is an extremely stable element and poses a potential threat to water supplies. All of the herbicides should be handled carefully and in accordance with the specifications outlined by the manufacturer or distributor.

To obtain proper concentrations of chemicals to provide safe and economical control of submergent vegetation, correct water volumes must be carefully established. The herbicides previously mentioned are relatively non-toxic to fish and other aquatic life. However, some of the herbicides and newer algicides impart strong tastes and odours to water and proposed uses of them in the vicinity of municipal intakes have to be carefully assessed and perhaps restricted. Some of the 2,4-D compounds have been shown to impart tastes and odours at 1/700 the concentration normally used to provide control of aquatic plants and some of the algicidal formulations impart odours at concentrations as low as 47 p.p.b.
Control of Mosquitoes and Black Flies

With respect to toxicity to fish and other aquatic life, the insecticides as a group are much more toxic than the herbicides. Two main groups of organic insecticides have evolved the chlorinated hydrocarbons and the organic phosphates. The former group includes such chemicals as endrin, aldrin, dieldrin, and DDT, all of which are toxic to animal life at low concentrations. Endrin is the most toxic of this group, killing fish in laboratory toxicity tests at a level of 1 part per billion.

DDT is the chemical used most commonly to control black flies and mosquitoes and is very effective for these purposes. In controlling black flies, the chemical is applied as a 5 to 10 percent solution of DDT in fuel oil, at a rate of .1 ppm of active ingredient. In larvicidal operations for mosquito control, at 5 to 10 percent solution of DDT in fuel oil is used at a rate of .25 lbs. of active DDT per acre. Adult black flies and mosquitoes may be controlled by aircraft or ground spray operations, at a similar rate of ½ lb. per acre.

While DDT has been used very often in larviciding programs without producing immediate mortalities of fish, it is a very stable compound and is known to accumulate in the organs and fatty tissues of fish that come in contact with it or feed upon aquatic insects and other organisms that may accumulate the chemical. The long-range effects of the chemical on aquatic life are not entirely understood. It is to be hoped that a highly effective and less toxic chemical will be developed for black fly and mosquito control in the near future.

Control of Coarse Fish

Rotenone is the chemical used most frequently for controlling undesirable species of fish. Its use in streams must be confined to situations where a pond is present on the stream to provide dilution and so protect waters down-stream from the area of treatment. Ponds are usually drained prior to treatment so that a period of several days will be required for the pond to re-fill, during which time the chemical will detoxify. Experimental work is now anticipated to determine how effectively Potassium permanganate may be used as a detoxifying agent. Rotenone will control most species of fish at 0.05 to 0.1 ppm of the active chemical. Commercial preparations of rotenone are available as 5% and 20% wettable powders and 10% liquid emulsifiable concentrates.

Control of Leeches and Swimmers' Itch

These two types of aquatic nuisances are considered together because the usual method of control is the same for each. Copper sulphate is used in beach areas to safeguard swimmers at a rate of 3 pounds per 1000 square feet. This chemical will kill the snails that serve as the intermediate host for the swimmers' itch organism. It will kill leeches or drive them from the area although some usually escape treatment by burying themselves in the mud at the bottom. Because copper sulphate is toxic to fish and aquatic invertebrate life at the high concentration necessary, proposed applications must be given careful consideration. Swimmers must not use a swimming area for a period of 48 hours following an application at this rate.
The cercariae that cause swimmers' itch usually penetrate the skin of bathers as water droplets evaporate. Brisk rubbing with a coarse towel will kill the cercariae and largely prevent infection.

The best control for leeches is to maintain a clean beach by raking and removing aquatic weeds either mechanically or chemically. Debris and vegetation harbour small aquatic animals upon which the leeches feed.

**Summary**

The forms of plant and animal life that may create problems in the aquatic environment here in Ontario have been reviewed. A brief resume of methods of control, the effects of chemicals on fish and other aquatic life, and other aspects related to the use of aquatic pesticides, has been provided. Additional literature or information related to the control of aquatic nuisances may be obtained by writing the Ontario Water Resources Commission, Biology Branch, 801 Bay Street, Toronto, Ontario.
CURRENT METHODS FOR THE TREATMENT
OF DOMESTIC AND FOOD PROCESSING WASTES
FROM SUBURBAN AND RURAL AREAS

INTRODUCTION

In the past five years many advances have been made in the art of sewage treatment. New solutions have been discovered for old problems. Interest in water pollution control is high. Not since the introduction of the activated sludge process as early as 1916 has the profession of sanitary engineering experienced such enthusiasm. The need for improved domestic sewage treatment methods became apparent immediately following the Second World War when development resulting from the mass movement of people from cities into surrounding municipalities greatly exceeded the construction of interceptor sewers and central sewage plants. Suddenly, there was a demand for interim and semi-permanent sewage facilities to serve subdivisions, shopping centres, motels, schools, restaurant-service stations, and other developments. Small plants for such duty were required to be highly efficient, economical to build and simple to operate.

During the same period, some industries which produce large volumes of organic wastes consolidated their operations in large plants, centrally located in rural communities. As a result of this change in activities and the general increased public interest in pollution abatement, it was necessary for these industries to develop better methods of waste treatment.

In response to this challenge sanitary engineers have developed, constructed and placed in operation waste stabilization ponds; spray irrigation systems; and modified activated sludge plants including extended aeration, contact stabilization, complete mixing in aerated basins and oxidation ditches. The above methods are now used for many applications in place of septic tanks with effluent sand filters; high-rate trickling filters; and conventional activated sludge plants (which are more familiar to you).

These new processes have helped to solve the difficult sludge disposal problem. Waste stabilization ponds will function for years without requiring sludge removal. The extended aeration process creates a minimum amount of excess sludge. Contact stabilization plants are presently being provided with aerobic rather than anaerobic digesters to avoid septic odours and to reduce the amount of treated sludge to be handled.

Although a major breakthrough has not been achieved at large, municipal plants, improvements to mechanical sludge handling equipment have been made. These include vacuum filters, centrifuges, incinerators and dryers.

A number of proprietary processes have been introduced such as Zimmerman, A. S. T. (Atomized Suspension Technique) and Densi-Sludge.
Also, the efficiency of the conventional anaerobic digestion process has been increased by the use of mixing devices and two-stage digestors.

From this brief outline of recent achievements in the field of sewage treatment you can appreciate that this cannot all be adequately described and discussed in one, two-hour lecture.

Based on some knowledge of your work and interests, I have elected to confine the balance of my remarks to the use of modified activated sludge plants and waste stabilization ponds for the treatment of domestic and food processing wastes.

MICROBIOLOGICAL AND ENVIRONMENTAL FUNDAMENTALS

Stabilization of all organic wastes is brought about by the activities of microorganisms. Activated sludge plants, trickling filters, stabilization ponds and the self-purification of rivers operate on the same fundamental biological principles. A brief description of the micro-organisms which inhabit all aerobic biological treatment systems and their environmental requirements will assist in understanding the basic principles behind the design and operation of the sewage treatment process to be discussed in this presentation.

Classification of Micro-Organisms

The important micro-organisms contributing to the purification of organic wastes are as follows:

Bacteria

Bacteria are single-celled plants which grow in the form of rods, cocci or spirals as single cells in pairs, clusters or chains. They are difficult to observe under the microscope requiring 430 X or 970 X magnification and are best seen in stained preparations. Their average size is 1.5 x 1.0 microns (1000th of a millimeter).

The diverse biochemical characteristics of bacteria make it possible for them to metabolize most, if not all, organic compounds found in sewage. Growth of any particular species is dependent upon its competitive ability to obtain a share of the available organic material in the system. The species with the fastest growth rate and the ability to utilize most of the organic matter will predominate.

One of their most important characteristics is their ability to flocculate. All of the aerobic biological waste treatment systems depend upon this flocculation ability for the separation of colloidal organic solids from the liquid phase for purification purposes.

Fungi

Fungi are multicellular plants. They can be seen at 100 X under the microscope and are easily identified. The filamentous fungi form large masses of cells with a width of several microns.
Fungi are of secondary importance and they can, like bacteria, metabolize almost every organic compound found in sewage.

Under normal environmental conditions fungi will be present and will aid in the stabilization of organic matter, but bacteria will predominate.

The filamentous nature of most of the fungi found in wastes, however, makes them undesirable since they do not form a tight, compact floc and do not settle easily.

Algae

Algae are single or multicellular plants which contain chlorophyll and other photosynthetic pigments to permit use of sunlight as a source of energy. A few algae can utilize soluble organics for food in the absence of sunlight. They can be seen at 100 X and are identified by the presence of the photosynthetic pigments, green, blue-green, yellow-green, brown and red. The single-cell forms are slightly larger in size than bacteria.

Chlorophyll-containing algae, under the influence of strong and prolonged sunlight, are able to produce oxygen according to the following simplified equation

\[
\text{sunlight} \quad \begin{array}{c}
6\text{CO}_2 + 6\text{H}_2\text{O} \\
\rightarrow \\
\text{C}_6\text{H}_12\text{O}_6 + 6\text{O}_2 \\
\text{(cell food)}
\end{array}
\]

The carbon dioxide required for this photosynthesis is partly derived from bicarbonate ions contained in sewage, but the main source of carbon dioxide is from the biochemical oxidation of organic matter caused by bacteria and other micro-organisms.

Oxygen production is directly proportional to algal densities. Under favourable conditions supersaturation of dissolved oxygen may result.

Protozoa

Protozoa are single-celled animals. Seen at 100 X power under the microscope they range in size from 5 to 400 microns. They are responsible for reducing the number of free swimming bacteria, thus aiding in producing a clarified effluent. Numerous species of protozoa are found which feed on algal cells. The type of food and the competition for food are the major factors which determine the predominance of protozoa species.

Higher Animals

Rotifers are multicellular animals which occur in highly stabilized aerobic purification systems.

Crustaceans are also multicellular animals but with hard shells around the body. The crustaceans are macroscopic since they are large enough to be seen without the aid of a microscope. They grow well in stabilized aerobic utilizing bacteria, fungi and algae as their major source of food, resulting in a clear effluent.
ENVIRONMENTAL FACTORS

The growth of any or all types of micro-organisms will depend upon the environmental limitations of the particular sewage treatment system. The main environmental factors to be considered are:

Nutrients

Microorganisms require definite chemical elements to form protoplasm.

For bacteria to grow at their optimum rates, they require an excess of nitrogen in the form of ammonium salts and phosphorus as phosphates.

For their growth and reproduction algae in addition require carbon, mainly in the form of carbon dioxide and bicarbonate ion as well as magnesium and calcium.

Should any of the main components be in short supply, growth and reproduction will decline. Metabolism will cease completely when one of the elements is seriously depleted or absent.

It is fortunate that domestic sewage contains sufficient of the above nutrients and in reasonably correct proportions to support a dense bacterial and algal population. Industrial wastes, however, may upset this nutritional balance. Depending on the nature of the industrial wastes present it may be necessary to add nutrient chemicals to restore the proper balance.

pH

Most micro-organisms grow best between pH 6.5 and 8.5 with little adverse effect from pH 6 to 9. Death is not complete unless the pH is down to about 4.5 or up to about 10.5.

Bacteria predominate at the neutral pH range. If the pH should drop below 6, the fungi will predominate over the bacteria due to their ability to grow in acid pH.

Algae will cause the pH to rise through their use of carbon dioxide from the bicarbonates in water. The remaining hydroxide alkalinity will cause the pH to rise. Above pH 9 algae growth is quite limited unless abnormal conditions exist.

Oxygen

In aerobic systems oxygen has no effect on the metabolic reactions as long as it is in excess of 0.5 ppm. In natural pond systems oxygen is supplied from the breakdown of organics, algal photosynthesis and diffusion from the atmosphere at the liquid interface. In activated sludge plants oxygen is supplied by diffused air or mechanical aeration devices. In trickling filter plants it is obtained by diffusion from the atmosphere.

Temperature

Microbial reactions respond to temperature the same as any chemical reaction. The rate of reaction increases with higher temperatures and decreases with lower temperatures. The rate of the biochemical reactions doubles with each 10°C increase up to about 37°C to 42°C at which temperature the common organisms are killed.
The temperature favourable for optimum bacterial and algal development in sewage treatment systems is considered to be about 20°C.

**Sunlight**

Sunlight is an important environmental factor in the successful operation of natural stabilization pond systems.

Algae need sunlight of sufficient intensity and duration for the maximum production of cell food and oxygen. The quantity of sunlight falling on a surface is not only dependent on the inclination of the sun, but also on altitude and on weather conditions. Areas in mist belts or where prolonged cloudy conditions occur are less suited for algal development than arid regions.

**Wind**

In stabilization ponds, wind is required for the natural mixing of the oxygen produced by algae in the upper layers of liquid with the oxygen depleted liquid in the lower depths.

**EXTENDED AERATION**

**ACTIVATED SLUDGE TREATMENT PLANTS**

Development of the extended aeration process began with studies on the treatment of dairy wastes in 1948. About the same time an underloaded conventional activated sludge plant in Ohio was operated with a 100% return of final settling tank sludge to the aeration tanks with no sludge wasted. An excellent plant effluent was produced. In 1950 three, extended aeration plants were installed for the treatment of milk wastes in Ohio. In 1951 the Ohio State Department of Health approved the first plant of this type for the treatment of sanitary sewage from an industry. Since this beginning in Ohio, extended aeration plants have accelerated greatly in interest and development.

The first extended aeration plant in Ontario was built in 1958 to serve the Shell Oil Company Limited service station and restaurant on Highway #400, west of King City. There are now thirty-three approved installations in operation. These small plants ranging in capacity from 500 to 100,000 U.S. G.P.D. serve schools, institutions, subdivisions, motels, military bases, shopping centres, camps, a bowling alley and a creamery. In addition there are five municipal plants ranging in size from 0.1 to 3.0 MGD in service or under construction at the Town of Paris, Town of Burlington, Village of Elora, Township of Moore and Township of Westminster.

This treatment method envisages stabilization of organic matter under aerobic conditions, with disposal of the end products into the air as gasses and into a receiving stream in highly suspended or soluble form. The conventional process is simplified by the elimination of the primary settling tank and the anaerobic sludge digestion unit. The sludge handling problem is minimized by a reduction in the quantity of sludge accumulated for disposal.
Raw sewage is pumped or flows by gravity through a trash trap, bar screen or comminutor into an aeration tank. Settled sludge, pumped or air-lifted from the final settling tank is mixed with the raw sewage as it enters the aeration tank.

The aeration tank is sized to give a retention of 24 hours based on the average daily flow. The BOD loading on the aeration tank is up to 20 pounds per 1000 cubic feet of tank. The conventional activated sludge process has a loading factor up to 35 pounds of BOD per 1000 cubic feet.

The amount of air to be supplied to the aeration tank varies from about 3,000 cubic feet of air per pound of raw BOD in plants with 9 feet deep aeration tanks to 1500 cubic feet in plants with 12 feet deep aeration tanks. In diffused air plants two blowers should be provided, one for stand-by service. Provision should be made for adjusting the air supply such as time clocks or different sheaves on belt drives.

Usually a spray system with nozzles is furnished for the control of foam in the aeration tank.

The activated sludge is passed on to the final settling tank which is designed to give a retention of four hours at design flow. The return sludge facilities are sized to remove an average of 100 per cent of the raw sewage flow at all times.

A skimming device should be installed in the settling tank to return to the aeration tank floating solids retained on the surface between the inlet and effluent baffles.

Effluent from the settling tank may be discharged to a stream or be given any of the following additional treatment processes, chlorination, effluent sand filtration, or polishing in a pond having a retention time from one to four days.

In addition, sludge holding tanks are required at most plants for storing sludge wasted from the main treatment process until it can be hauled away by scavenger truck. The capacity of the sludge holding tank varies from one to four cubic feet per capita equivalent contributing population.

Flow measuring facilities, laboratory equipment, fencing and access road are other desirable features of extended aeration plants.

**SMALL CONTACT STABILIZATION**

**ACTIVATED SLUDGE PLANTS**

The contact stabilization process is a modification of the conventional activated sludge process which has been developed from the study and alteration of certain overloaded, municipal plants in the United States.

The first prefabricated "package" sewage treatment plants were installed in the United States in 1958. As of October, 1962, the original manufacturer listed 117 plants each serving from 100 to 10,000 persons. A further 23 installations each serving from 400 to 5,000 persons were listed by a second manufacturer as of July, 1962. To date, there have been only three contact stabilization plants approved for use in the Province of Ontario.
In 1962, a 5,000 USGPD prefabricated plant was installed by the St. Lawrence Seaway Authority to serve the North Channel Bridge at the City of Cornwall. Approval was given in 1963 for the construction of a 0.54 MGD contact stabilization plant to serve the Town of Picton and a 30,000 USGPD prefabricated unit to serve the Regina Mundi Seminary in the Township of Westminster.

The Contact stabilization process is based on the fact that the composition of fresh domestic sewage is only 15 - 25% soluble organics, but 75 - 85% colloidal and suspended solids.

In this process raw sewage is rapidly mixed in a contact tank with activated sludge from the re-aeration tank to adsorb out colloidal and suspended material. Adsorption is an instantaneous reaction based on the surface area of the sludge, requiring only about 10 minutes contact time. In order to remove the soluble organic material the mixing period is extended to at least 1.5 hours based on the average daily design flow. The volumetric loading for the contact tank is in the order of 70 pounds of BOD per day per thousand cubic feet of tank capacity.

The activated sludge with its adsorbed material is then passed into a settling tank. The retention time in the settling tank may range between three and four hours. After the settled sludge has been collected by mechanical scrapers; it is pumped or air-lifted from the settling tank to a re-aeration tank adjacent to the mixing or contact tank.

In the re-aeration tank the micro-organisms convert the solid organic material that has been adsorbed on their surfaces to the soluble stage. The soluble organic material is then absorbed or taken into the cell structure of the micro-organisms where it is stabilized, that is, converted to energy, cell tissue, water and carbon dioxide. Sludge from the re-aeration tank flows into the contact tank to be mixed intimately with the raw sewage, thus completing the cycle. The re-aeration tank is sized to give a detention period of at least six hours at design flow.

Aerobic sludge digestion tanks are frequently included as an integral part of the contact stabilization plant for final digestion and stabilization of waste-activated sludge from the system. The aerobically digested sludge may be disposed of by methods commonly employed for the disposal of anaerobically digested sludge. The aerobic digestion tank is usually sized to give a capacity of three cubic feet per population equivalent of the raw sewage.

The air requirement for the aerobic digester is about 500 cubic feet of air per pound of five-day BOD in the raw sewage or 15 - 20 CFM per thousand cubic feet of tank volume. The amount of air required for the contact, and the re-aeration tanks is at least 1500 cubic feet of air per pound of five-day BOD in the raw sewage.

As in the extended aeration process, the rate of sludge return from the settling tank to the re-aeration tank averages about 100% of the average design of flow. Also, provision should be made in the design of the settling tank for automatic skimming of scum.

**WASTE STABILIZATION PONDS**

On the North American Continent the ponding of raw sewage or partially treated sewage as a means of stabilizing organic wastes was carried out during the 1920's in the southwestern United States where sunlight and temperature were most favourable for maintaining suitable aesthetic conditions. The satisfactory operation of a sewage pond at Santa Rosa, California, was reported in 1924.
This example was followed by the community of Fessenden, North Dakota, which constructed a raw sewage pond in 1928. Observation of this pond indicated that satisfactory operation could be obtained in northwestern areas of the United States regardless of severe weather conditions.

Immediately following World War II a number of modern-day ponds based on sound engineering principles were installed in North and South Dakota. Since 1948, the construction of municipal waste stabilization ponds has spread to many areas of the United States.

Waste stabilization ponds were also introduced into western Canada in 1948. There are now over 288 ponds serving municipalities from British Columbia to Manitoba.

The first municipal waste stabilization pond to be built in Ontario was constructed at Cardiff (Improvement District of Bicroft) in the year 1956. This installation was followed by the 15½-acre ponds in three cells at the Town of Wiarton; the 69-acre ponds in two cells (43 and 26 acres) at the Town of Listowel and the 9½-acre ponds in two cells serving the Village of Stirling, all placed in operation in 1960.

TYPES OF PONDS

There is much confusion in the literature concerning the nomenclature for sewage ponds. The terms "stabilization pond", "sewage lagoon" and "oxidation pond" are often used interchangeably. The term "stabilization pond" may be used to describe all classifications of ponds. In some areas of the world the word "lagoon" is associated with the lagooning of raw sludge which is an anaerobic process. Ponds deliberately designed to utilize anaerobic decomposition of organic material could very appropriately be referred to as "anaerobic sewage lagoons".

Conventional stabilization ponds may be classified as facultative ponds since they usually combine aerobic and anaerobic biological processes.

By its name, the "oxidation pond" is an aerobic treatment device. The term "oxidation pond" should, therefore, be reserved for those ponds which are aerobic under all conditions of loading and weather. Ponds equipped with aeration devices would be included in this category.

A description of each type of pond follows in order to further explain the treatment processes which take place in them.

Anaerobic

Anaerobic ponds are designed to establish conditions which encourage methane fermentation. They may be as much as ten feet deep, have a small surface area to volume ratio and may be loaded in excess of 400 lbs of 5-day BOD per acre per day. BOD removal efficiencies up to 70% have been experienced with retention periods between 2 and 4 days.

In anaerobic ponds the major fraction of the applied waste is decomposed through methane fermentation. In the absence of air predominantly facultative bacteria commonly known as acid formers break down cellulose and starches to simple sugars and proteins to amino acids. The build-up of acid end products lowers the pH. A second group of obligate anaerobic bacteria commonly known as methane formers develops which utilizes the organic acids. As this group increases the acids are metabolized to carbon dioxide and methane.
The metabolism of the amino acids liberates ammonia which in turn raises the pH to a more favourable level for the acid formers. As long as a proper balance is maintained between the acid formers and the methane formers the process functions properly.

Because of the release of hydrogen sulphide, ammonia and the creation of foul smelling compounds anaerobic ponds may be odorous and therefore must be carefully located with respect to populated areas and travelled highways. Since effluents from anaerobic ponds usually have BOD's in excess of 40 ppm, they require further treatment before discharge to a water course.

Anaerobic ponds followed by secondary ponds for the treatment of domestic wastes have not been approved for Ontario. They have been used, however, in Australia in the western United States and in western Canada where adequate isolation from dwellings is readily available.

**Conventional (Facultative)**

Conventional stabilization ponds are designed with a large surface area to volume ratio. In Ontario, loadings are ordinarily confined to 20 lbs of 5-day BOD per acre per day or 100 persons per acre per day. The operating depth is usually controlled between three and five feet. Most of these ponds, however, are unavoidably facultative devices subject to both aerobic and anaerobic processes.

As stated earlier, organic matter in the raw sewage is decomposed by both bacteria and algae. The bacteria produce carbon dioxide and water from the decomposable organic compounds in the waste. The algae manufacture their own food by the process of photosynthesis. The oxygen released by photosynthesis together with dissolved oxygen absorbed from surface aeration should maintain the system aerobic, that is, with excess oxygen during the daylight hours.

At night, when both the bacteria and the algae are demanding oxygen, the upper layers may turn anaerobic if the dissolved oxygen level is not adequate to sustain aerobic processes. Also, in winter, low water temperature and interference with light penetration by ice and snow cover cause a decline in biological activity. As a result, the conventional pond may become completely anaerobic.

Odours may be associated with ponds having excessive sludge deposits and also may occur for a few days during the ice break-up period in the spring. Experience has now demonstrated that these ponds can be located as close to habitation and other developments as can other sewage treatment processes. This should be at least 1500 feet from any dwelling.

In Ontario, as of January 1, 1964 there are 15 municipal ponds in operation serving municipalities having populations between 600 and 11,000 persons and 23 others under construction. In addition there are 25 other approved domestic waste treatment ponds serving subdivisions, schools, institutions, military establishments, camps, resorts and combined service-station-restaurants.

A preliminary evaluation of treatment results indicated that the annual average effluent concentration from 15 installations was 24 ppm BOD and 41 ppm suspended solids. Generally, effluent quality can be improved by operating ponds in series in order to reduce the number of algae present.
Aerobic

In aerobic ponds organic matter is decomposed through the mechanism of aerobic oxidation. Underloaded conventional ponds or secondary ponds operated in series with conventional ponds come under this classification.

Aerobic conditions can be maintained artificially in the liquid at all times by supplying additional oxygen by means of mechanical aerators or by air-diffusion pipes placed along the bottom of the pond. The land area required for ponding is then reduced by raising the BOD loading per acre and by increasing the operating depth.

As the system loading is increased, the aeration volume decreased and the air increased, a point is soon reached where the agitation is sufficient to prevent deposition of solids. Under such circumstances the suspended solids content of the treated waste becomes the same as the equilibrium suspended solids concentration in the pond itself. When the suspended solids content exceeds the desired treated effluent concentration it is necessary to settle the waste in a second, polishing pond before discharge to the receiving stream.

The microbial characteristics of the aerated pond are more like those of an activated sludge system. The turbulence and turbidity prevent normal algae growths. The bacteria present form typical activated sludge floc.

Aerated ponds are presently being designed with detention periods from 4 to 20 days. The operating depth selected may vary from 8 to 15 feet depending upon the area of land available. The surface loading varies with the depth used and the strength of the waste applied.

These ponds have been shown to give BOD removal efficiencies as high as 75% on domestic, tomato canning and paper mill wastes and up to 90% when followed by a polishing pond.

A mechanically aerated pond followed by a conventional pond has been constructed in the Township of Sandwich West to serve a combination of domestic and dairy product wastes.

The first of three ponds treating potato processing wastes in the Town of Alliston has recently been equipped with a diffused-air aeration system. In conventional ponds and also in most "aerobic" ponds settleable solids in the raw waste together with those colloid and dissolved solids converted to settleable solids by the biological action of the bacteria and algae, and dead micro-organisms form a uniform sludge blanket over the bottom of the pond. The settled solids are in turn decomposed anaerobically. Unless there is an area of deep solids deposition because of poor circulation such as at the pond inlet, the oxygen demand exerted by this benthic decomposition is not sufficient to turn the upper layers anaerobic.

ORGANIC INDUSTRIAL WASTE APPLICATIONS

These types of stabilization ponds may be grouped in any of the following combinations to form a complete organic industrial waste treatment installation:

(1) A single facultative pond;

(2) A number of facultative ponds in parallel and/or series;
(3) An anaerobic pond followed by one or more facultative ponds;

(4) An anaerobic pond followed by an aerobic pond followed by one or more facultative ponds;

(5) An aerobic pond followed by one or more facultative ponds.

**Fruit and Vegetable Canneries**

Presently in Ontario there are about 26 canneries utilizing the waste stabilization pond method in various forms. The depth of these ponds varies from 1.5 to 25 feet deep. Ten of these installations have no screens. This results in the formation of a surface scum which impedes the entry of sunlight into the ponds. Generally speaking sodium nitrate has not been used. Few samples have been collected to determine the strength and effect of these untreated lagoon wastes when discharged to receiving streams during the spring run-off period.

Insufficient waste flow data are available to accurately calculate 5-day BOD surface loadings. By assuming that the process waste flow is one half the total water use the 5-day BOD loading per acre per day ranges from 300 to 900 lbs. These may therefore be classified as anaerobic ponds. Only the lower loadings have not resulted in objectionable odours.

**Manufacturing of Dairy Products**

Since dairy wastes putrefy very rapidly, it is essential to keep them aerobic at all times to mitigate the release of offensive odours.

Dairy wastes may be successfully treated by means of stabilization ponds, but the loading must be kept in the order of 20 lbs 5-day BOD per acre per day. Such extremely strong wastes such as whey and buttermilk should be excluded.

In Ontario, where there are many slaughterhouses and meat-packing plants with low volume discharges, at least 12 single and multiple cell pond systems are in operation. Loadings in the order of 50 lbs BOD per acre per day have been used at ponds where isolation is good. Where odours may be a problem, loadings have been 20 lbs BOD per acre per day as for domestic sewage ponds.

**Poultry Processing**

One of the first industrial waste stabilization pond installations in Ontario was for a poultry processing plant. There are now about five poultry processing plants in Ontario using this method of waste treatment. Blood, feathers, evisceria and sometimes grease are removed ahead of the ponds. These ponds operate with a range in loading from 20 to approximately 60 lbs BOD per acre per day. Five-day BOD removal efficiencies up to 94 per cent have been obtained. Odours are experienced in the spring for periods up to 4 weeks on the more heavily loaded ponds.
LABORATORY SERVICES

AND

SIGNIFICANCE OF ANALYSES

INTRODUCTION

It has long been recognized that the services provided by laboratories are an essential part of our higher standard of living. This holds true whether these laboratories function as part of hospitals, health centres, industries, water treatment plants, sewage treatment plants, or of provincial agencies such as the Ontario Water Resources Commission. Hospital doctors expect their laboratories to supply them with a great deal of information about their patients' conditions, medical officers of health look to the analyses from regional and other health laboratories to pin-point actual or possible trouble spots, industries use analyses to check quality of products, chlorine residual and jar tests, to name two out of many, are used to determine correct dosages of chemicals in water treatment plants, samples are analyzed to determine the effect of sewage plant effluents, many and varied bacteriological, biological, chemical and other analytical results are supplied to the Ontario Water Resources Commission as a necessity to support its various activities.

Before the Ontario Water Resources Commission came into being, this need for laboratory facilities was accepted by the Provincial Board of Health of Ontario and continued by the Ontario Department of Health. In 1907 a laboratory called the Experimental Station was established about four or five blocks from the present Canadian National Exhibition grounds. This station started in a small way the present work being done by the OWRC laboratory and its initial report concerning the "Factors in the Design, Regulation and Action of Slow Sand Filters" appeared in the 1912 Annual Report of the Provincial Board of Health. Later activities expanded to include bacterial and chemical analyses on water, sewage, and milk samples.

Prior to the formation of the Ontario Water Resources Commission this station was part of the Sanitary Engineering Division of the Ontario Department of Health. When it began functioning in April 1957, the Commission took over most of the duties and personnel of the above Sanitary Engineering Division. At that time, it was realized that, to carry out all of the laboratory functions made necessary by the increased scope of the Commission, better laboratory facilities had to be provided and as a result, the planning and construction of the present laboratory commenced.

At the time this new laboratory was being planned, a fire in the Experimental Station caused it to be condemned and its staff moved to an old abandoned school and remained there until the new laboratory was completed.
At the time the new laboratory was being planned, the work being carried out embraced not only chemical and bacteriological analyses but also the biological aspects of conserving our water resources and preventing their pollution. Before the formation of the Commission, the discharge of industrial wastes and their treatment was not required by legislation unless an actual health hazard existed. However, because of the tremendous industrial growth in the province, the investigation and correction of the effect of these wastes became imperative and became the responsibility, in a large part, of the Industrial Wastes Branch of the Division of Laboratories. Similarly, the development of new laboratory methods, assessment of treatment equipment in use in water, sewage and industrial waste treatment plants and similar projects was considered a necessity that could well be accomplished in the laboratory and so this task was assigned to another group in the division.

So it was on March 28, 1960, when the Division of Laboratories moved into the new building, its duties were being conducted by five branches, Bacteriology, Biology, Chemistry, Industrial Wastes and Purification Processes.

SERVICES

In discussing services that are rendered by the laboratory, I will include some suggestions regarding the method of taking the samples that will, if followed, enable us to provide even better service to the individuals and groups that submit samples or request our assistance in the field.

The laboratory receives samples from all over the province, a few from outside the province, and the staff also analyzes and conducts investigations for pollution of boundary waters. The samples from within the province are submitted by our Commission personnel, other government departments and agencies, municipalities, industries and individuals and receives and responds to requests for field investigations from the same sources. In 1963, approximately 56,000 samples were analyzed by personnel of the Division of Laboratories necessitating almost 182,000 determinations.

Bacteriology Branch

The Bacteriology Branch supplies information concerning routine water pollution work, slime forming organisms and associated problems, intestinal bacteria, and similar services of a bacteriologic nature. Samples are submitted routinely to this branch to detect sewage pollution or its source using the coliform indicator group of bacteria. These samples consist of drinking and industrial waters requiring the highest purity, untreated well and surface drinking waters, river and lake waters, industrial wastes and domestic sewage. These samples are submitted by the groups mentioned above.

The analytical results supplied on these samples include coliform enumerations by the Membrane Filter (MF), most probable number (MPN), and indicated number (IN) techniques, fecal coliforms (E. Coli) by the MPN technique, fecal streptococci by the MF and MPN methods on certain samples and total bacterial or enteric bacterial counts by a variety of agar plating methods. The analytical results most routinely supplied are those for coliform density using the membrane filter technique.

This branch also runs tests to assist in the solution of problems caused by organisms such as: sliming in streams; bulking in sewage treatment plants by filamentous bacteria; water colored in distribution systems, wells and elsewhere by iron utilizing organisms; tastes and odours by bacteria, molds, actinomycetes and filamentous sulphur slime organisms; and corrosion and odours produced by sulfate-reducing
(or hydrogen-sulfide-forming) organisms. To aid it in these tests, the total bacterial population is employed as a useful parameter in evaluating the extent of some of these problems. Many of the tests vary widely and require special techniques that are not written up as specific bacteriological procedures and the bacteriological personnel must devise their own culture, staining and microscope procedures. All of this information is readily available to those that can make use of it. Sometimes branch personnel will make an on-the-spot field investigation to observe the condition and thus provide more information on the causative organism.

In many of these problems the questions asked are: What is it? What is causing it or supporting its growth? and, What can be done to get rid of it? Therefore, to answer all these questions it is not only necessary to identify the organism, but also to determine what it needs to flourish, that is, its nutritional and physical requirements, and then to determine the ways of eradicating it or reducing its numbers below the nuisance level. Only by developing a programme to learn all these facts can answers be supplied that are of benefit to the people inconvenienced by these problems caused by these nuisance organisms.

Since a great deal of the work done concerns fecal pollution it is only natural that the branch keep fully informed of and well versed in the latest techniques used in determining the numbers of the organisms contributing to this type of pollution. To provide the best service to the people sending in the samples the varied results reported by researchers must be substantiated and, if this is done, the method of obtaining these results must be adapted because of our numbers of samples. In certain cases, a certain procedure produces good results but would not be feasible where large numbers of samples were involved.

Similarly, the service or result supplied is in many cases only the end product of a large amount of other work that is not apparent. The bottles that we supply for taking bacterial samples must be washed, sterilized, labelled, and, in some cases, shipped. All our equipment used in the tests must be sterile and media and dilution bottles must be made up and sterilized. Similar operations must be performed before any results can be considered reliable enough to be released.

This branch has also worked on the development of a depth sampler to be used for taking samples that are truly indicative of the bacterial conditions that exist at the depth that the sample was taken. The sampler must be so designed that the handling of it will have no effect on the water sample when it is collected.

This branch hopes to be able to evaluate the significance of streptococci as indicators of fecal pollution to supplement the use of coliforms and fecal coliforms. To do this, suitable media and techniques for the isolation and enumeration of these bacteria are being studied.

Frequently, the senior branch personnel are called upon to discuss results that have been obtained on samples sent in and to instruct on the best procedure to use to collect samples that are meaningful. We hope that for any one sample sender the information is not supplied in this order but that instructions on how to take samples are requested before the samples are sent in. In an attempt to supply instructions before samples are taken an information and instruction sheet is included with every shipment of bottles. A sample of this instruction sheet is included as an appendix to this paper.
Biological Branch.

The Biology Branch also receives samples for bioassay tests, algae counting, and identification of the aquatic life therein. The analysis of samples does not occupy the same proportion of time in this branch that it does in the Bacteriology or Chemistry Branches. A large amount of time is spent in field investigations and administering the regulations pertaining to the application of algicides and herbicides in the province.

Many samples are received from health officers that contain various forms of aquatic life. The branch personnel are asked to identify them and comment on their public health significance. Occasionally the identification of the aquatic forms prompts a field investigation to determine the numbers involved, their source and means of removal as a public health hazard or nuisance.

The Biology Branch is interested in the numbers of algae, their types, the effects they produce, both physical and chemical, on the waters in which they are living. The more information that the branch has regarding this, the more it can pass on to the parties that are directly interested or affected. Information of this type is often gathered by making field investigations and collaborating with other branches and divisions within the Commission and also other agencies in defining the cause of a problem and trying means of overcoming it.

From the information gathered in this manner, certain procedures can be suggested and tried. For example, it is known that algae can and will cause tastes and odours in water supply depending on the numbers present. It is also known that certain algae produce certain tastes or odours such as grassy, nasturtium, geranium, skunk, garlic, violet, cucumber, musty, aromatic, fishy, and septic and that, in some cases, numbers determine whether the odour will change, for example, from geranium to fishy. This branch will, time and personnel permitting, visit a municipality to determine whether a taste or odour problem is caused by algae and attempt to solve the problem. In a recent case at Belleville, a very bad taste developed caused by the Alga Synura and a member of this branch, working with the Purification Processes Branch found that break-point chlorination could remove the taste.

This branch also assists in problems at waterworks where excessive numbers of algae drastically shorten the time of the filter runs. This occurred in Lake Ontario and the problem affected all the municipalities from Hamilton to Kingston. Assistance was given to identify the algae and determine means of overcoming the difficulty.

Certain algae, namely the blue-greens, when growing in large numbers in water can render the water toxic to animals drinking it. A number of cattle were killed some years ago after drinking some water from Sturgeon Lake that had a very prolific growth of algae in it. When no other causes of death could be determined, microscopic examination of the water showed that the blue-green alga was the culprit.

Since the personnel of this branch are limited in number and therefore cannot be at every municipality when a problem develops, an algae counting course has been set up to train operators at these various waterworks so that they can (1) determine what algae are normally present and their numbers and (2) determine whether the numbers are increasing. It is hoped that this course will enable operators through experience to determine the types and numbers of algae that cause problems at their waterworks. This will allow them to institute corrective measures before the problems develop. This information being collected by the operators is also being tabulated by the branch so a province-wide picture can be developed for future use. So far, 12 operators have been trained and are sending in results to be tabulated.
In the field of water pollution control this branch also conducts biological surveys on streams in the province to determine the effect of waste discharges on the biota. It is known that certain aquatic insects and animals define polluted or unpolluted areas by their presence or absence. By examining and sampling the stream or lake in question, it can be determined whether pollution does or does not exist or has existed at some time or other. If organisms that are normally present in unpolluted water are present in sufficient numbers it means that no pollution is occurring or has not occurred recently. If not present, it can safely be assumed that there is pollution present or, if not present at the time of sampling, that it has occurred and the organisms have not yet had a chance to re-establish themselves. Thus, the information obtained by this type of sampling covers a period of time and is not limited to the time when the sample was collected.

Information of this type is useful when conducting surveys before sewage treatment plants or industries begin discharging their wastes. The results can be used as a datum by which all future results can be assessed. Similarly, surveys of this type can be used to show improvement in a stream that is already polluted.

This branch also investigates and records fish kills both for information and the possibility of legal action. In a good many cases, the cause is not definitely known but is only a suspicion which is difficult to use in any prosecution. However, the twenty cases that were reported to us last year were categorized as having the following likely causes:

- **Pesticides** - 7 e.g., spraying insecticides
- **Industrial discharges** - 6 e.g., mining and organic oxygen depleting wastes
- **Municipal discharges** - 4 e.g., causing oxygen depletion
- **Natural reasons** - 1 e.g., winter kill
- **Unknown** - 2

The branch is hoping to improve the reception of information so that the investigations can be made promptly and the cause positively determined. Persons like yourselves can assist greatly by reporting fish kills as soon as possible and supplying all the information considered necessary and possibly collecting samples of the water and dead fish.

If a large enough sample of water is received, say, a Winchester or a gallon, the branch personnel can carry out a bio-assay and determine whether there are any toxic constituents in the water and the level of such toxicants.

The same procedure is used to determine if an industrial discharge is or will be toxic to fish and at what level. A median tolerance limit is obtained using various concentrations of the actual or expected discharge. One-tenth of the 48-hour median tolerance limit (48-TLM), which means the concentration at which 50 per cent of the test fish will die in 48 hours, is usually considered safe for discharge. This branch has done a great deal of toxicity studies on herbicides. This has been covered in a previous paper which explained how this information is used.

The Biology Branch has conducted studies in Lake Ontario, Erie and Huron to determine the reason for the excessive growths of the alga Cladophora and what practical means are available for its control. This alga grows prolifically along certain shorelines when chemical and physical conditions are suitable. When washed ashore, it creates all the effects of decomposing sewage and is very objectionable. The use of algicides, reduction of nutrients in the water, and mechanical removal are being studied.
Another special study being conducted by this branch at the request of fishermen in the lower St. Lawrence River is the effect of certain industrial wastes on the taste of fish. A taste panel is presently studying the taste of fish from above and below the suspected cause of the taste.

Aquatic life as it affects water and is affected by the quality of the water is a complicated concept. Our biology staff are always willing to assist with interpretation and correction and control of problems within the limits of their capabilities.

Chemistry Branch

The Chemistry Branch in its function of providing analytical data and advice to the staff of the OWRC and to senders of samples is called upon to detect rather wide-ranging varieties of substances. Anything which may impair or enhance the quality of water and for which there is some possibility of detection through analytical chemistry may logically be said to be the concern of this branch. While the bulk of our samples are provided by the field staffs of the OWRC, analytical assistance is provided to the other agencies concerned with water pollution and water supply problems. In the field of water pollution, this branch supplies analytical data on a number of tests for: 5-day Biochemical Oxygen Demand, known more familiarly as BOD, chemical oxygen demand, total and suspended solids, the various nitrogen compounds, pH, the various toxic compounds, arsenic, cyanide, chromium, copper, nickel, cadmium, zinc and other metallic compounds, the taste producer phenol, alkyl benzene sulphonates known better by its abbreviation ABS and oils and greases. Other tests are run but these will give some idea of the wide variety.

For information regarding water supplies, the branch analyzes, on a routine basis, water samples for hardness, alkalinity, chlorides, iron, pH, and fluoride. Non-routine tests are performed for sulphates, silica, magnesium, sodium, calcium and others.

In these fields of water supply and water pollution there are a number of analytical problems as yet unresolved; in particular, there are a number of tests which cannot be reliably performed at a central laboratory, due to the evanescent nature of the substance which is the subject of the test. Many of these require that the determination be performed in the field upon a freshly collected sample. Dissolved gases, such as, dissolved oxygen, carbon dioxide, natural gas, and others are the most obvious examples. In these cases, even the method of collection of the sample can appreciably affect the analytical result obtained. Other substances almost equally impermanent in character include residual chlorine, sulphides, pH, ferrous iron, volatile solvents, and some natural organic materials, particularly those responsible for musty, earthy and other 'natural' types of objectionable odours.

Some other tests can only be reliably performed if the sample is preserved. In all cases of preserved samples, haste in delivering the samples to the laboratory is also essential. Where microbial attack may diminish or alter the substance in question, refrigeration in the dark to a temperature of less than 5° C. (41° F.) is usually temporarily effective and is most applicable to those samples which contain organic pollutants which are intended to be tested for BOD, suspended solids, nitrogen compounds, chlorine demand or odour threshold. Specific preservatives and separate sampling containers are usually required for tests for cyanide, phenols and some other unusual pollutants. Directions for special preservative techniques can be obtained by consulting the branch staff prior to the collection of samples.
In some cases, samples need not be preserved if they are delivered within a few hours of collection, especially where it is only necessary to know if a substance is present or absent in order to know how to solve a problem, as is the case when pollution involving a substance usually entirely absent in natural waters is being traced.

Tastes and odours in water present problems for which a solution through the use of analytical chemistry is usually lacking. Taste tests can be risky because there is seldom assurance that the sanitary quality of samples is above suspicion. The test remaining in this case is the threshold odour determination and the person affected is usually in the best position to detect traces of odour. The best way to check for odour traces in a water supply is to spray hot water in a shower. The fleeting nature of these odours is one reason why a householder may complain of an overpowering odour, the health inspector can often barely detect it, and no trace can be found by the time the sample arrives at the laboratory.

It is often impossible to identify the nature and cause of an odour. There is good reason to believe that, in most cases of odours in water supplies, minute traces of volatile organic substances are responsible, but there is seldom any means of detecting them. Odours can be produced by many organic substances at concentrations as low as small fractions of a part per billion, far below the normal limits of detection other than by odour.

Although the odour cannot be identified as a particular substance, the problem is not necessarily insoluble, since our micro-biologists claim that many of the musty and earthy odours may be due to the products of the activity of bacteria or algae. In these cases, the results of an examination of the sample for bacteria or algae may suggest a solution. Many of the odour-producing chemicals involved, even though unidentified, are susceptible to straightforward treatment and thus can be removed.

Contamination of water by petroleum products is another water supply problem for which an analytical answer is not apparent. We have consistently been unable to recover for direct measurement and identification those levels of petroleum products whose presence is indicated only by a characteristic odour, even when this is distinct. The presence of phenolic materials, which are common constituents of petroleum products, and which can be detected at levels as low as 2 parts per billion, can be taken as indirect confirmation of the presence of petroleum products when these can be detected by odour. In the case that visible quantities of the petroleum product are present, as much of the contaminant as possible should be collected. If the collected sample is sufficiently large, (a teaspoonful or more) the grade of product involved, that is, gasoline, kerosene, light or heavy fuel oil, lubricating oil, can be determined. It is unlikely that the brand or manufacturer can be identified. Few oil companies can themselves identify their products among a collection of unlabelled samples. The problem is equivalent to that of identifying, analytically, not only a grade of milk, but the dairy in which it was processed.

This branch is always ready, as are the other branches, to assist anyone with a problem in technique or procedure. In certain cases "short cuts" are known, or conversely experience has shown where "short cuts" can not be used and the complete procedure must be used.
Sampling Comments

This seems like an opportune place to further review sampling procedures since they affect the service which a laboratory can provide. The reliability of an analytical report can never be better than that of the collection and handling of the samples. The sample should be "representative" but, admittedly, this is hard to define and an; given definition would be unlikely to apply for all types of sampling. A 'representative'sample is one that best captures the aspect of water quality under consideration. For example, if information as to the normal or average quality of a water is desired, the sample should be collected under 'normal' conditions as free from disturbing influences, as possible. Sampling lines should be flushed, bodies of water should be sampled near their centre of gravity, and flowing waters should be sampled during 'average' flows etc. Particulate matter which settles quickly should be avoided in such samples, on the assumption that it would remove itself from the water under examination by settling and would not 'normally' be present.

On the other hand, when problems are being investigated, particularly if the analysis is aimed at identifying or confirming the presence of a suspected pollutant, a 'representative'sample is one that cram as much of the problem substance as possible into the sampling container. In this case, selective sampling techniques are indicated, to any degree necessary to ensure that an ample amount of the problem substance is present in the sample. Odour identification samples should be collected when they are most intense. If this happens when water has remained in the piping system for some time, then the sample should be collected at such a time without flushing the line.

If visible material such as sediment, particulate matter, oily substances or floating films, is the subject of complaint then concentration of the material is often desirable. Collecting large samples in any convenient container, followed by any or all of the following techniques can provide sufficient material for analysis: settling, decantation, siphoning, manual collection, skimming, adsorption on an inert carrier (paper, cloth fibres, etc.) or any other manner which is applicable. In this regard it should be noted that the field of analysis employed in water chemistry is 'trace analysis', in which the analyst would, by choice, work with an indefinitely large sample in which even minute traces of material would be present in substantial total amounts. Limits of detection are often dictated by sample size. Samples of 40 ounces are often insufficient when a number of low-level detection tests need to be performed, or in any case for more than 6 - 8 determinations on one sample. Sediments are particularly misleading in regard to the actual quantity of solid material present. Samples which appear objectionably turbid in the sampling bottle often yield, after the sediment is filtered off and dried, only a milligram or two of the dried sediment. This is sufficient only for one or two trial tests which may turn out to be false leads, in which case all the effort in obtaining and forwarding the sample has been wasted.

With unusual or non-routine samples, the appropriateness and effectiveness on an analytical investigation is usually proportionate to the background information provided with the sample. Thus, it is of utmost importance to our analytical staff that as much background information be supplied concerning effect, the possible source, suspected material in the sample, any rhythm or pattern associated with the occurrence of the problem, and whether the knowledge of a constituent's presence is sufficient or is the concentration also necessary. If these answers are furnished with the samples we will be in a much better position to supply a worthwhile service.
Industrial Wastes Branch

The Industrial Wastes Branch deals with the origin, reduction and control of wastes of all types arising from industrial processing operations throughout the province.

In evaluating specific industrial problems the branch personnel conduct an investigation during which they inquire into the volume of flow, the processes from which the wastes are derived, the timing and duration of these flows, and the outfalls from which these wastes are discharged. Samples are collected of these wastes and from the analyses and the information gathered a good picture, can be obtained concerning the effect of these wastes on the receiving sewers, treatment works or surface waters. The complete evaluation is reported to the industry and other interested parties such as the municipality and the medical officer of health. In such a report recommendations are made for the correction of such problems that are caused by the discharge of these wastes.

The branch also carries out comprehensive surveys of the entire industrial waste loadings in municipalities. This usually means visiting all the industries that by their nature are reliably certain to have liquid wastes or who are known to use large quantities of water. The reports on these industries are usually collected and submitted to the municipality as a single report accompanied by suggestions to the municipal engineer to assist him in cleaning up any problems caused by these wastes in the municipal sewerage works. These municipal surveys serve to provide information for use in the design and operation of new or proposed treatment plants. Where malfunction of treatment plants is attributed to the influx of industrial wastes, these personnel locate the source, evaluate the characteristics of the wastes, and recommend appropriate remedial action.

The branch is presently gathering information to update a suggested by-law for the guidance of industries and municipalities. This by-law is intended to assist municipalities in the preparation and implementation of their own sewer use by-laws and the imposition of surcharges where necessary.

Industries discharging directly to watercourses are appraised of OWRC objectives and are advised in the reduction of complete removal of offending constituents. This includes assistance in planning the treatment facility and the necessary analytical and control procedures.

The branch reviews plans and proposals for industrial wastes treatment facilities and recommends approval of such proposals, makes pre-installation inspections and follows the construction, the trials and run-in. It consults with other branches of the Commission concerning sampling the waters to which an industry will be discharging so "before" and "after" comparisons can be obtained.

Liaison is maintained by the branch with industrial management. Consultations are arranged to review overall programmes on a continuing basis to urge management to undertake waste control and treatment as an integral part of industrial operation. Senior management committees have been set up on an industry-wide and or area basis for this purpose in the petroleum petrochemical, meat packing, pulp and paper, and uranium mining industries. The participation of personnel from other branches or other government departments is requested where desirable in dealing with industrial management and specialists who are involved in deliberations at this level.
Members of the staff are called upon to give lectures to various groups, and are also invited to address business and industrial bodies.

In general, the branch is endeavouring to develop a programme in which industry and various trade groups participate on a voluntary basis. Emphasis is placed on the promotion of confidence in and understanding of the Commission's objectives for water quality, and on the development of realistic pollution control programmes that will not adversely affect the competitive position of one industry with another. To avoid unnecessary restrictions, each plant is considered on its own merits. Due to the variation in circumstances it is felt that uniform standards can not always be applied. Many of the older plants in Ontario face an almost insurmountable task and it is often necessary to stage improvement over a period of several years. New industry, on the other hand, is asked to provide suitable treatment at the outset.

PURIFICATION PROCESSES BRANCH

This branch was formed with the idea of providing a technical service in the field of water treatment. Water in this case refers not only to potable water but includes sewage and industrial waste. A group of engineers and technicians has been formed who are familiar with the chemistry of water treatment and are capable of giving technical assistance to the operators of our water treatment plants. They are equipped to carry out special tests at the plants for such things as coagulation, stability, taste and odour control, pH, dissolved oxygen, oxidation potential, rate of oxygen utilization, gas analyses and other tests. If need be, they are also equipped to make microscopic examinations for algae and slime bacteria in waters and the biota present in sewage sludges.

Where the treatment plants are equipped to carry out chemical tests, the personnel of this branch are on call to instruct the operators in methods and techniques of water analyses. These tests are very necessary to ensure that these plants are operating efficiently and safely and these tests are only meaningful when the proper procedures and techniques are used. One instance that I can recall occurred where a water plant operator was running a chlorine as chloride test in the belief that he was determining residual chlorine. This is, of course, a rarity, but that fact did not make it less dangerous to the people using the water.

This group also acts in an advisory capacity on chemical problems in water with personnel from other branches of the Commission, with consulting engineers, with other government departments such as Health, Lands & Forests, and with industries.

Investigations into new equipment are also carried out. For example, mechanical surface aerators have recently come into prominence. Tests have been made in the laboratory and in the field on a number of different designs of mechanical aerators and their efficiency has been calculated. This makes it possible to compare the efficiency of the different designs of mechanical aerators and also to compare this type of aeration with other types.

Similarly, equipment installed by manufacturers that is claimed to be intended for use in a control capacity is checked to determine if it can be used in that way and if it can be used in the treatment plant without the assistance of highly trained personnel.
New testing equipment is also checked. For example, membrane type dissolved oxygen meters have been put on the market by a number of manufacturers during the past year. A number of these have been brought into the laboratory and checked against known procedures to see if they could be of use to Commission personnel in the field and in the laboratory and to determine their advantages and disadvantages. The branch personnel are always willing to assist potential users of equipment by relaying any information they might be aware of concerning that equipment.

Additional Services

In addition to the analytical and investigational services provided by the Division of Laboratories in the laboratory building, the Commission maintains a library of much of the current information on water and pollution control. If any public health inspectors would care to drop in to the library and read up on any item that was of interest they would be welcome.

SIGNIFICANCE OF ANALYSES

The following compilation was prepared for the most part by the New York State Department of Health, Division of Laboratories and I have made additional comments. It lists the more important determinations that are made in water quality testing.

<table>
<thead>
<tr>
<th>Determination</th>
<th>Significance</th>
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<tbody>
<tr>
<td>Dissolved Oxygen (DO)</td>
<td>Dissolved oxygen is one of the most important indicators of the condition of the water. It is necessary for the existence, propagation and migration of many forms of aquatic life. The knowledge of the oxygen content is essential for the study of waste discharges and the pollution effects on the receiving waters. It is also of significance in evaluating the corrosiveness of water.</td>
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<tr>
<td>Biochemical Oxygen Demand (BOD)</td>
<td>The biochemical oxygen demand test is one of the most important tests in determining the degree of pollution in streams at any time. BOD with DO can be used as a basis for evaluating the purification capacity of waters. The BOD is an indicator of the oxygen that will be consumed by wastes in the stream thus affecting the dissolved oxygen content of the stream.</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>The chemical oxygen demand test is used for determining the pollutional strength of sewage and industrial wastes. This test measures the unstable organic matter and biologically resistant organic and inorganic matter that is not determined by the BOD test. It can sometimes be related to the BOD test, if all the factors are known.</td>
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Ammonia Nitrogen (NH₃-N)

The test for ammonia nitrogen indicates the freshness of sewage in waters and the effectiveness of previous treatment to which the sewage has been exposed. The ammonia nitrogen test, together with a knowledge of the pollutional loads to which a stream is exposed, is an indication of the assimilative capacity of the stream to accommodate wastes discharges.

Nitrates (NO₃-N)

Nitrates are usually present in relatively small quantities in unpolluted surface waters and any increase in their concentration is an indication of pollution by wastes from industrial, domestic and agricultural sources. It has also been shown by many investigators to have a definite link with the occurrence of methemoglobinemia in infants (blue babies).

Phosphates (PO₄)

Phosphates are an indication of the possible introduction of detergents into the waters, and they have a direct bearing on the rate of growth of aquatic life. They are also indicative of industrial wastes, surface runoffs containing fertilizer, and also of pollution by domestic sewage.

Sodium and Potassium Na K

Sodium and potassium, although usually found in low concentrations in most waters, are sometimes abundant in waters as a result of industrial pollution; and at higher concentrations, the sodium and potassium have a degrading effect on soil used for agricultural purposes.

Chlorides (Cl)

Although chlorides are usually present in most natural waters, many sewage or waste discharges cause abnormally high concentrations in the waters. The corrosiveness of the water is increased by chlorides, and tastes are imparted to the water. An abnormal fluctuation of the chloride content of the water is usually an indication of pollution.

Hardness

Hardness is a character which determines the usefulness and economic value of water for many purposes. Hard water forms scale in boilers, heaters, radiators, and pipes and adversely affects the flow and heat transfer and enhances boiler failure. Hard water used for domestic purposes results in a higher consumption of soap and detergents.
<table>
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<tr>
<td>Alkalinity</td>
<td>Certain industries have specific tolerances of alkalinity that they can cope with. Alkalinity also affects the treatment required for waters at water treatment plants when water is to be used for both industrial and domestic purposes. Alkalinity and acidity values are also indications of the ease with which pH values can be brought to the neutral point.</td>
</tr>
<tr>
<td>Iron and Manganese</td>
<td>Iron and manganese at small concentrations are capable of staining laundry, porcelain, and fixtures. When waters containing iron and manganese are exposed to the air, the water becomes turbid and unacceptable from an aesthetic viewpoint. Both the iron and manganese interfere with laundry operations and cause difficulty in water distribution systems by supporting growths of iron bacteria.</td>
</tr>
<tr>
<td>Fluoride (F)</td>
<td>Although fluorides are commonly used in drinking water to decrease the incidence of tooth decay, higher concentrations cause mottling of the teeth. An abnormal fluctuation of the fluoride content in water is usually an indication of pollution by industrial wastes.</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>Calcium causes hardness in water and, together with magnesium, is responsible for the formation of boiler scale. Many industrial applications require waters with very low calcium content.</td>
</tr>
<tr>
<td>Phenol</td>
<td>Phenol when present in very minute concentrations in water will cause a definitely unpleasant medicinal taste when that water is chlorinated. Phenol is an indication of pollution by industrial wastes.</td>
</tr>
<tr>
<td>Carbonates and Bi-Carbonates</td>
<td>High concentrations of carbonates and bicarbonates in water result in the release of carbon dioxide in steam boilers and hot water facilities greatly enhancing the corrosiveness of the water. Excess carbonates can also be injurious to plant life when water containing high concentrations are used for irrigation.</td>
</tr>
<tr>
<td>Determination</td>
<td>Significance</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Alkyl Benzene Sulfonate (ABS)</td>
<td>The alkyl benzene sulfonate determination is an approximate measure of the detergents in water. With the widespread use of detergents coupled with the stability of this compound, detergent pollution was becoming a prevalent problem throughout the United States. At concentrations of above 1.5, the detergents cause foaming.</td>
</tr>
<tr>
<td>Cyanide (CN)</td>
<td>Cyanides are a very toxic chemical, even at low concentrations, and are included in the waste of certain industrial processes.</td>
</tr>
<tr>
<td>Sulfates (SO₄)</td>
<td>Sulfates, in conjunction with calcium and manganese, form permanent hardness and hard scale in boiler operation. Certain industrial applications have specific tolerance for sulfates; and in high concentration, sulfates tend to have a laxative effect when used for human consumption.</td>
</tr>
<tr>
<td>Conductivity</td>
<td>Conductivity of water is a measure of its capacity to conduct a current of electricity. It is a fast and useful determination, and the conductivity changes in proportion to the quantity of the dissolved minerals in the waters. Changes in the dissolved mineral content of the water could be caused by natural conditions or pollution.</td>
</tr>
<tr>
<td>Temperature</td>
<td>Temperature affects the biological and sanitary characteristics of a stream. Water at a higher temperature has a lower capacity for oxygen than water at a lower temperature. Variations in the temperature of the water can be caused by waste discharges or natural seasonal or air fluctuations of temperature.</td>
</tr>
<tr>
<td>Hydrogen-Ion Concentration (pH)</td>
<td>Hydrogen-ion concentration is an indicator as to whether water is acid, neutral, or alkaline. It is measured in terms of pH, and the degree of acidity is directly related to the corrosive properties of the water, the corrosive activity being greater at lower pH values. The pH helps to determine the method of water treatment prior to human consumption.</td>
</tr>
<tr>
<td>Colour</td>
<td>Coloured water is an indicator of either suspended or dissolved matter. Although it could be undesirable strictly from an aesthetic point of view, it could also be indicative of harmful wastes in the waters.</td>
</tr>
<tr>
<td>Determination</td>
<td>Significance</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Odour</td>
<td>Odours are an indication of dissolved gases or wastes in waters and often necessitate special treatment for removal to render the water satisfactory for domestic or industrial usage.</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Turbidity is significant in surface waters in regard to both industrial and domestic usage. Certain industrial processes can tolerate specific turbidities, and the degree of turbidity of waters for domestic use determines the treatment necessary before consumption.</td>
</tr>
<tr>
<td>Total Solids</td>
<td>The total solids test is a measure of both the dissolved and suspended solids in water, and many industrial applications have specific limits in regard to the water used. The total solids test is also a measure of the settling characteristics of a stream.</td>
</tr>
<tr>
<td>Settleable Solids</td>
<td>The settleable solids test is a good indicator as to the degree and type of treatment that water would have to be given prior use for both industrial and domestic purposes, and the test is also indicative of the efficiency of upstream sewage treatment plants discharging to the waters.</td>
</tr>
<tr>
<td>Coliform Bacteria and other Micro-organisms</td>
<td>The test for coliform bacteria of the surface waters indicates the degree of pollution. Coliform in water indicates the presence of waste from the intestinal tract of humans and warm-blooded animals; and thus, they indicate the possible occurrence of disease-producing bacteria from the same source. Water heavily contaminated with bacteria and other organisms also causes slime formation on pipes and equipment used in industrial processes utilizing the waters.</td>
</tr>
<tr>
<td>Plankton</td>
<td>Plankton organisms interfere with water use by shortening filter runs involved in treatment plants; and they also cause tastes, odours, colourations, and various physical and chemical changes. A study of the type of Plankton in waters, together with their frequency of occurrence, provides reliable information for perfecting proper treatment and making maximum use of the water. Many Plankton organisms are beneficial for providing food and oxygen for desirable aquatic life and aiding the stream in recovering from wastes discharges.</td>
</tr>
</tbody>
</table>
Pesticides, Herbicides, and complex organic chemicals are being used more widely each year. They are very stable compounds and are hard to remove from waters once they are introduced into them. These chemicals are responsible for fish flesh tainting and the impairment of water quality for industrial and human consumption. The carbon adsorption unit is an extraction apparatus for removing these chemicals from the water for making subsequent studies on the types and concentrations of contaminants.
SANITATION PROGRAMME EVALUATION

An evaluation of an environmental sanitation programme of a Health Unit or a Health Department is available from the Ontario Department of Health through the Environmental Sanitation Branch.

The purpose of an evaluation study is to provide an exchange of good sanitation and administration practices which can be passed on from one health agency to another.

The usual reason for the acceptance of such a study by the officials of a health agency is to take advantage of all of the resources available to improve their environmental sanitation programme, both in the traditional and new areas of Public Health and to achieve the maximum gain to meet the needs of the area they serve.

In the preparation of an evaluation study it is desirable to know as much as possible about the area and the people involved. This is part of planning and organization to assist in understanding the area in relation to the present environmental sanitation programme.

For example it is pertinent to know the area involved in square miles, the population, population density, transient population industrial workers or vacationists, the main occupation of the people and general wage scale, the topography of the area, soil types and climate.

Prior to the field work information is requested on the working conditions, personnel policies, and extent of inspectoral duties and responsibilities of the chief inspector and the staff.

The field work begins with a discussion with the Medical Officer of Health. The general programme of the inspection staff is discussed and enquiries are made as to any phase of the work which would require special attention. Usually arrangements are made to attend a meeting with the Board of Health to discuss the purpose of the evaluation with them.

Considerable time is spent with the Chief Public Health Inspector, observations are made of the office accommodation with regard to space available and office working arrangements.

Office Procedure

An office system should be planned to reduce to a minimum the time required by an Inspector in the office to complete reports. It is considered that an Inspector's primary duty is in the field and not in the office. As much as possible, routine reports should be completed in the field at the point of inspection. All forms and reports which are left with the operator of any establishment should be completed in duplicate, using carbon paper.
This type of form should be carefully prepared to assure that the information required is correct in relation to the applicable regulation. Printed types of forms complete with the county or municipal crest, date, name and address of the Health Unit, etc. should be used in preference to forms run off by an office duplicating machine, especially when used in dealing with the public. The number of different inspection forms can be reduced if they are prepared in such a manner to apply to various similar types of inspections. Periodic reviews should be made of all forms to decide how frequently some of the information is used and its importance. The purpose of this is to save time and to prevent the accumulation of unimportant records. The impression that the Inspector leaves with the person interviewed in gaining his co-operation, is more important than taking too much time to complete a routine report on the usual facilities found.

With reference to the office filing system, the most important requirement is to be able to locate a file when it is needed. It is important that the contents of a file clearly indicate complete information for the Medical Officer of Health, without the necessity of depending on verbal information from the Inspectors or trusting the memory of what took place at an inspection made some time in the past.

Duties of Chief Public Health Inspector and Staff Public Health Inspector

From observation a more efficient organization is obtained when the duties of the chief public health inspector and the staff public health inspectors are clearly defined and laid down in writing. Such a policy should be approved by the Medical Officer of Health and the Board of Health. As an example, the following could be considered as direct responsibilities of the chief inspector to the medical officer of health.

(a) To be responsible only to the Medical Officer of Health; or in his absence, the person authorized to act for him.

(b) To carry out the programme established by the Board of Health and the Medical Officer of Health in accordance with the instructions and intention of the Medical Officer of Health and to confer with him on any modifications of the programme found necessary in the field.

(c) To keep the Medical Officer of Health fully informed of events and situations of environmental public health significance.

(d) To keep the Medical Officer of Health informed on matters arising which might involve the Board in litigation.

(e) To keep the staff informed of the Medical Officer of Health's instructions and intentions and to ensure that these are carried out.

(f) To keep himself and the Medical Officer of Health informed of new developments in the field on environmental sanitation and to suggest modifications in the programme or procedure if these are justified.

(g) To confer with the Medical Officer of Health on special problems and to advise him on the specialist services available from the Department of Health.
The Chief Public Health Inspector's responsibility to the Public Health Inspector field staff could be as follows:

1. The supervision of the work as performed by the Public Health Inspectors.

2. The administration, planning and organization of the inspection programmes.

3. To assure that equal work distribution is provided for each inspector in order that the services may be evenly distributed over the entire area.

4. Office duties, to keep accurate records of the Inspectors' activities, quality of reports, workload, forms used, travelling accounts, daily and monthly reports, provide information to the public and to answer enquiries.

5. For making decisions on matters which have been referred to him by the Inspectors. He should be prepared to make field visits with the Inspectors to assist with problems and to establish a time limit for the completion of recommendations and if they are not completed, discuss them with the Medical Officer of Health in order to make a definite decision as to what action is necessary.

6. Arranging educational programmes, creating good public relations, attending meetings with School authorities, Municipal and County officials, Welfare Agencies and groups of people, to further the interest of good sanitation practices.

7. Ensuring that the Inspectors are following the policies as provided under Federal, Provincial and Municipal legislation.

8. The proper use of the Inspector's time in the office and in the field, to assure that the demand for services is being fully met, and that the Quality of the work rendered achieves satisfactory results.

9. Emphasizing fixed inspections during the off-seasons, for example, restaurants and retail food stores. These establishments should be brought to a satisfactory standard prior to the summer inspection activities, so that the number of inspections can be reduced if necessary when other seasonal work demands more attention.

The Responsibilities of the Public Health Inspectors could be as follows:

(a) The Public Health Inspectors are responsible to the Chief Inspector. They should deal directly with the person involved in an inspection, if other persons are concerned with the same subject the Chief Inspector should be brought into the matter, for example, school inspection requiring meeting with School Board or School Inspector, where a business manager prefers the Inspector to deal through the parent company, and where assistance or an opinion is required from another government or municipal agency. All instructions regarding the Inspectors' work by other personnel of the Health agency or other persons or officials of the municipality, should first be directed to the Chief Inspector for his attention.
(b) The Public Health Inspector be responsible for the inspection of every phase of the work within his district, including all programmes as directed by the Chief Inspector. If for any reason complete coverage is unable to be carried out, the Chief Inspector should be advised immediately. The Inspectors should arrange their routine work schedule so that all inspections can be completed in one area at the same time. This is preferable rather than to conduct a single inspection between separated points and not to make routine inspections in the same area.

(c) Activities should be avoided which do not correspond to Health agency activities. Co-operation should be extended, but should not conflict with those responsible for the enforcement of Federal, Provincial or Municipal legislation.

Administration Policy

It is very desirable to have an administration policy outlining the procedures which are to be taken in connection with each phase of an inspection programme. For example, on dairy inspections the policy should include a copy of the milk plant regulations, a sample of the type of report an inspector prepares on an inspection, the manner in which milk samples are to be collected, frequency of collection, the action which is to be taken when adverse phosphatase results occur, the procedures to be taken when unsatisfactory bacteriological results are reported, the factors to be taken into consideration when recommending or withholding the issuance of the Certificate of Approval.

If such an administration policy was established for the various duties it could be used as a reference for the inspectors to follow in most circumstances and provide uniformity in the sanitation programme.

Personnel Policies

Every Health agency should have a policy outlining the working conditions and benefits. This might seem incongruous, but it has been noted on a number of occasions where an inspector was not familiar with fringe benefits. Such a policy should be available to each member of the staff and should include salary range: the arrangements for annual vacation: sick leave remuneration: pension plan arrangements: medical care plan etc. Good personnel policies denote efficiency, the maintenance of a high calibre of staff, job satisfaction, reflected in the quality of work performed.

Inspectors' Activities

In preparing an evaluation, priority is given to the conditions which affect the greatest number of the public, or situations which are a potential health hazard. We could consider the following in these categories:

Food control
Water supplies
Sewage disposal
Housing
Communicable disease
Insect and rodent control.
The importance of these categories may change, depending on the area under evaluation.

In dealing with each category, specific information is obtained as to what procedures are carried out for inspection, the number of establishments, frequency of inspection, frequency of sampling, what action is taken with regard to an unsatisfactory condition and the length of time the unsatisfactory condition has been in existence. The activities are then weighed in terms of the number of staff, the area covered, and work load distribution.

Observations are made as to the degree of concentration on items of real public health significance, compared to the time spent on matters of lesser importance.

During an evaluation, each inspector is accompanied on routine inspections. The object here is to note the problems of each inspector. The evaluation is made in terms of work performance rather than any reference to personalities. It is not the intention to enter into a discussion between an inspector and an owner, but rather to observe the activities. Suggestions might be made to the inspector after the inspection. No attempt is made to solve technical problems at this time, however, experienced engineers, veterinarians and public health inspectors are available from the Environmental Sanitation Branch to provide advice to the health agency on any technical or unusual public health problem.

Evaluations have been made of Municipal Health Departments as well as Health Units and require some variations in the approach to the programme. For example, the work load may be different, lacking septic tanks, private wells and other similar situations. However, in some phases of the work, the frequency of the inspections is increased due to the density of the population, and the fact that the facilities are used extensively.

In some environmental sanitation programmes, the Public Health Inspectors specialize in one phase of the work. On other areas a generalized programme calls for an inspector to cover all the work in the district. It has been noted amongst the inspectors that there are varying degrees of preference as to which type of programme is preferable. It is very difficult for one inspector to be an expert in all phases of sanitation. There are advantages in either system of arriving at the same end of providing an efficient programme. In a generalized programme, in some cases, it appears to be a good idea to arrange for an inspector who has a particular interest in a certain phase of the work to become a local expert in this field in order that the rest of the staff may call on him for advice. For example, an inspector might have a flair for public health law, or dairy inspections, or private sewage disposal systems, etc. This idea might be encouraged.

Public Information and Public Relations

There appears to be a lack of emphasis on this subject. This involves the approach of the Public Health Inspector and his method of dealing with the various types of people with whom he comes in contact on his regular duties. The Public Health Inspector should continually review the manner in which he deals with people, so that he may improve the desired co-operation expected, when enforcing regulations and promoting good public health practices.
There are many opportunities to develop programmes of interest to specific groups. For example, restaurant owners and employees, swimming pool operators, summer camp operators, septic tank contractors, etc., in order to provide information and to create a better understanding of what the health unit is endeavouring to achieve by its function. In any programme of public health education, the use of literature, films, newspaper releases, radio and other media, can contribute greatly to the message directed to the public. The effort to develop good public relations should not be overbalanced by a relaxation of the enforcement of regulations.

In some Health Units a monthly meeting of the staff is held and the inspectors are requested to give a short talk on any subject they choose. This helps to stimulate interest in the inspectors to carry out some research work on the various phases of sanitation. Along with this programme, whenever the opportunity presents itself, an outside expert is invited to participate. This is a good idea. We all need inspiration and encouragement to keep us working at top efficiency.

By-Laws and Licensing Regulations

The primary responsibility of any inspector is to carry out the instructions of the Medical Officer of Health and the Board of Health. This is often indicated by the by-laws and licensing stipulations which are passed by the Board of Health. In some areas which involve a great many by-laws, a by-law inspector is appointed. Thus the public health inspector is relieved to carry on the more important public health duties.

Where a by-law inspector is not employed, good administration practices will be maintained if the inspector's time is not concentrated on inspections dealing with the issuance of licenses which may all fall due at the same time, at the expense of more important public health work.

There is an ever increasing demand for the Public Health Inspectors' services in the traditional phases of the work, and in the new areas of emergency measures, hospital sanitation and perhaps air pollution studies. It is becoming increasingly evident that each Public Health Inspector should study and become more knowledgeable. This appears to be obvious by the more intensified course for Public Health Inspectors at Ryerson Institute, and the increase in the educational standards required before acceptance on the course.

Your attendance at this In-Service Training Course provided by the Institute of Public Health Inspectors reflects your interest in the field of Public Health. This course denotes progress and wise administration planning on the part of the Institute of Public Health Inspectors.
Ernest Mastromatteo, M.D., D.P.H., D.I.H.,
Division of Industrial Hygiene.

THE HEALTH ASPECTS OF INSECTICIDES
AND
PRECAUTIONS IN THEIR USE

Introduction

Pesticides are chemicals which are used to kill or control pests. The term pesticide covers many different groups of chemicals including miticides, rodenticides, fungicides, herbicides, and bactericides as well as insecticides. The main function of each group is indicated by the general term. Other related chemicals include plant defoliants, rot proofing agents, wood preservatives, plant regulators and fertilizers.

In this presentation only insecticides will be discussed with emphasis on the newer synthetic chemicals.

Benefits of Insecticides

The development of the modern synthetic insecticide has influenced the lives of many people. Some of their chief benefits include:

1. **Public Health** - The control of insects which transmit diseases such as malaria, typhus and yellow fever has affected great improvement of people in many parts of the world.

2. **Agriculture** - About 75 per cent of insecticide consumption is in the agricultural field in the production of farm goods.

3. **Natural Resources** - The protection of forest resources may require the use of insecticides. Even the development of tourist areas may depend upon these chemical agents.

4. **Property Damage** - Damage by insects to commercial, public and private buildings may be serious, as for example, with termites. Damage to goods caused by the clothes moth and carpet beetle is well known. Spoilage of stored food supplies by insects occurs. To these examples, there may be added the damage produced by insects to ornamental trees, lawns, flowers and home gardens.

5. **Aesthetic** - Insecticides afford relief from annoyance, irritation and the revulsion which some people have to the presence of insect pests.

Risks in the Use of Insecticides

Despite these benefits provided by insecticides, questions have been raised about their use. Concern has been expressed also about their possible health effects and their effect on wildlife.
Health effects may occur in workers engaged in research and development, in primary manufacture, in formulating plants, in mixing and in application. Apart from occupational exposure, there may be exposure to the public. Some people may be contaminated by spray drift in areas adjacent to handling or spraying of these materials. There is also the question of ingestion of small amounts of these materials as residues remaining on food consumed by the public. Insecticides also are a cause of accidental poisoning from ingestion, on the farm and in the home, especially in young children. The main point in consideration of such risks is that the benefits produced must justify their use.

Toxicity of Insecticides

In order to comment on the possible health effects produced by insecticides, some general remarks on toxicity and its measurement may be of value.

First of all, insecticides in common use present a hazard in varying degree to man and animal. Fundamental life processes in insects are surprisingly similar. The search for the "perfect insecticide" is still underway. Such an insecticide is one which is:

1. Effective for a wide range of insect pests
2. Easily and economically produced
3. Presents a low hazard to man and animals.

Toxicity is the inherent ability or property of a material which renders it able to produce poisoning. The word toxin is derived from the Greek word which means poison.

Toxic materials may gain entry to the body by:

1. Eating - This is termed ingestion or oral toxicity.
2. Breathing - This is termed respiratory or inhalation toxicity.
3. Skin Contact - This is termed percutaneous or dermal toxicity.
4. Injection - This is termed parenteral toxicity. This is done only under experimental conditions.

Toxic effects may be described as:

1. Acute - This generally refers to poisoning produced by a single large dose or exposure.
2. Chronic - This refers to poisoning produced by repeated small doses or exposures.
3. Subacute - This is intermediate between acute and chronic poisoning.
4. Cumulative - Poisons may accumulate in the body because the body is unable to rid itself of the material as quickly as it is absorbed. Lead is a classic example of a material which accumulates in the body and produces cumulative poisoning. Chlorinated hydrocarbon insecticides are stored in the body fat.
Cumulative poisoning may result also from materials which do not accumulate in the body but impair its function day by day faster than it can be repaired. Eventually, effects may be produced by a relatively small dose: An example of this type of poisoning is seen with the organic phosphorus insecticides and with the anticoagulant type of rodenticides.

**Toxicity Testing**

It is important to have some convenient measure of toxicity in order to compare the relative toxicities of insecticides and in order to group them as far as handling precautions are concerned. Toxicity testing is done on experimental animals. Measured amounts are given to these animals and the amounts which produce death or symptoms of poisoning are determined. The easiest to measure is death of the animal and this is used in assessing acute toxicity. Table I gives ratings or class of toxicity based on administration to experimental animals.

The terms used and the methods of deriving these measurements of toxicity are given below, according to the route of entry of the poison.

**Oral Toxicity**

1. **Acute Oral Toxicity** - The oral LD 50 dose is that single dose which when given by mouth kills 50 per cent of the animals under test. This test should be carried out on specified animals under standard conditions. Commonly, white rats are used. The dose is expressed as milligrams of insecticide per kilogram of body weight of test animal (mg./kg.).

2. **Subacute Oral Toxicity** - This is usually determined on dogs over a 3 month period and measured in terms of mg./kg.

3. **Chronic Oral Toxicity** - This is generally determined by feeding given concentrations of the insecticide in the entire diet of the animal. Usually, rats are fed over a two year period (their approximate life span). The doses administered are expressed in parts of insecticide per million parts of diet (ppm). Various dose levels are fed in order to determine:

   a. "No-Effect level" - This is the largest amount in ppm in the diet which can be given without detectable effects in the animal. The "no-effect level" is very important and residue tolerances for food for human consumption are generally based on it. A safety factor of 1/100 is commonly used for residue tolerances.

   b. Level which produces physiological, chemical or histologic changes without external appearance of damage.

   c. Level which retards growth.

   d. Level which produces clinical evidence of poisoning effects.

   e. Level which causes death.

Note is always made in chronic feeding studies of any other effects e.g. tumour growth.
Dermal Toxicity

(1) **Acute Dermal Toxicity** - The dermal LD 50 dose is that amount of insecticide which when left in contact with the bare skin of test animals for 18 to 24 hours produces death in 50 per cent of test animals. It is also expressed in mg./kg. Generally, guinea pigs and rabbits are used and the material is applied by a special cuff which holds it against the skin.

(2) **Chronic Dermal Toxicity** - This is not carried out on experimental animals.

Inhalation Toxicity

(1) **Acute Inhalation Toxicity** - Generally small groups of animals are exposed to saturated vapours of the insecticide in air for short periods commonly for 4 hours. The LC 50 dose is that concentration which kills 50 per cent of test animals after 4 hours' exposure. The Lt 50 dose is the time taken for a given concentration to kill 50 per cent of test animals. Neither the LC 50 nor the Lt 50 dose is commonly used. Concentrations are expressed as per cent or ppm of the vapour in air. For particulate matter e.g. dusts and spray mists the concentration is generally expressed as milligrams of the insecticide per cubic metre of air (mg./cu. m.).

(2) **Chronic Inhalation Toxicity** - Limited chronic inhalation studies have been carried out with insecticides. Certain figures have been proposed as threshold limit values for insecticide exposure by repeated inhalation. These values refer to air concentrations which would not be expected to produce evidence of toxicity for 8 hour working day exposures over a 40 hour work week. These values are based on experimental data and information from cases of poisoning where such information is available. These should be used as guides to the maximum permitted in the air breathed by workers. The threshold limit values are produced by the American Conference of Governmental Industrial Hygienists and they are revised annually. The values for insecticides are listed in Table II. The threshold limit values for insecticides may be compared with that for gases or vapours used as fumigants (Table III).

Parenteral Toxicity

(1) **Acute Parenteral Toxicity** - Acute parenteral toxicity may be determined by injection into different body sites. For example, if the insecticide is injected into the intraperitoneal cavity, the intraperitoneal LD 50 dose refers to that single dose which kills 50 per cent of test animals when given in this fashion. Similarly, there may be intravenous, intramuscular, subcutaneous, and other injection methods with their specific LD 50 terms.

(2) **Chronic Parenteral Toxicity** - This form of toxicity testing is not commonly done.
In toxicity testing, evidence of skin and eye irritation are carried out by applying the test material against the skin or instilling measured amounts into the eye. Testing to determine for allergic potential is more difficult. Often, human volunteers are used where this can be done.

**Relationship of Toxicity to Persons in Exposure**

The most common basis for comparison of the toxicity of insecticides is the oral LD 50 in white rats. A compound with a high oral toxicity, however, need not necessarily have a high dermal or inhalation toxicity as well.

Individuals applying insecticides may experience exposure chiefly by inhalation and skin contact. With some of the insecticides skin contact is more important than inhalation. Acute poisoning with ingestion occurs only as a result of accident or attempt at suicide.

**Toxicity and Hazard**

Toxicity is an absolute term. It is measurable to a degree by means of the animal tests mentioned above. The term hazard is not synonymous with toxicity - it is a relative term which indicates the risk involved in using any material. Hazard depends upon many things including: inherent toxicity, physical and chemical properties, conditions of use and the use concentration. Some very toxic materials may be used with very little hazard with proper care.

Assessment of toxicity does not necessarily include the ability of a material to produce cancer in test animals, or skin or respiratory allergies in man, but these are of importance in the use of the material. The fire and explosion properties, although important, are not covered with toxicity testing.

**Classification of Insecticides**

1. Inorganic Substances e.g. arsenicals, fluorides, silica aerogel

2. Organic Substances
   (1) Mineral Products
      (a) Petroleum e.g. kerosene
      (b) Coal Tar e.g. naphthalene
   (2) Plant (or Botanical) Products e.g. pyrethrum, derris, nicotine, ryania
   (3) Microbial Agents e.g. B. thuringiensis
   (4) Synthetic Chemicals
      (a) Chlorinated Hydrocarbon Compounds (CH)
      (b) Organic Phosphorus Compounds (OP)
      (c) Synthetic Pyrethrins
      (d) Synergists
      (e) Thiocyanates
      (f) Carbamates
Inorganic Substances

The arsenicals are of a high acute toxicity. They have been used in pest control work for many years and their toxicity is well appreciated. The oral LD 50 values for some arsenical compounds are given as: lead arsenate 1,050 mg./kg.; calcium arsenate 298 mg./kg.; and Paris Green 100 mg./kg.

Sodium fluoride may still be encountered as a roach and ant powder. The estimated human oral fatal dose is 4 grams. Such baits should be out of reach of young children.

Silica aerogel contains about 60 to 70% free silica in an amorphous form. It kills insects by desiccation. It is not toxic to humans but care should be taken to prevent prolonged exposure by inhalation.

Organic Substances

Petroleum products are used as solvents in many insecticidal formulations. Kerosene alone was commonly used for mosquito larviciding. In general, petroleum distillates are not of high toxicity. They do present a fire hazard.

Naphthalene used in moth control is obtained from coal tar. It is not considered toxic and cases of poisoning occur chiefly in children by ingestion. It should not be used in confined spaces where occupants continuously breathe the vapours e.g. closed bedroom.

Pyrethrum is a plant extract. It is of very low toxicity to humans but the dust may be irritating when inhaled. Pyrethrum has caused allergic responses in some individuals similar to ragweed pollen. It is not a skin irritant. Accidental poisoning by ingestion has occurred. Pyrethrum may be used in areas where food is handled. It has quick insecticidal action but has the disadvantage of a short residual period.

Derris roots contain rotenone as the active insecticidal agent. Rotenone is toxic to insects and fish but it is of low toxicity to humans. Swine are unusually sensitive to rotenone. The fine dust may be irritating to the skin, eyes and respiratory passages. Accidental ingestion is followed by gastro-intestinal irritation with nausea and vomiting.

Nicotine is an alkaloid which is extracted from the tobacco plant. The alkaloid is highly toxic with an oral LD 50 of 10 mg./kg. It is fast acting and penetrates the intact skin readily. Nicotine is commonly used as 40 per cent nicotine sulphate. In this form it is much less toxic and does not penetrate the intact skin.

Ryania is manufactured from the stem of tropical plants. It is of low toxicity to humans.

The use of microbial agents is still largely in the developmental stage. Bacterial strains which are not pathogenic to humans are used.

Much attention has been spent on the development of synthetic materials for insecticidal purposes. There are two main groups of these - the chlorinated hydrocarbon insecticides (CHI) and the organic phosphorus insecticide (OPI).
**Chlorinated Hydrocarbon Insecticides**

CHI are organic chemical compounds containing carbon, hydrogen and chlorine and sometimes oxygen, nitrogen or sulphur in their molecules. Some are simple compounds but others are complex and exist in many different isomeric forms.

They do have, however, some features in common and these are listed below:

1. Their exact mode of action in insects and in man are still not fully understood.
2. They are not protoplasmic poisons but exert their toxic action only after entering into the metabolism of the animal body.
3. Clinical tests for poisoning are not available.
4. They are soluble in fats and common organic solvents.
5. They are insoluble in water.
6. They accumulate in the body of animals; they are stored in the body fat.
7. They are similar in their toxic action.
8. They are stable organic insecticides and persist for relatively long periods after application.

**Acute Poisoning with CHI** - Central nervous system and gastro-intestinal symptoms predominate. The following symptoms occur: nervous irritability, hypersensitivity to stimuli, muscular tremors, nausea, vomiting, diarrhoea, convulsions, and coma. Death occurs from respiratory failure. In order to diagnose acute CHI poisoning, it would be necessary to have:

1. History of exposure
2. Neurological symptoms - tremors followed by convulsions

**Chronic Poisoning** - Chronic poisoning has been produced experimentally in animals by prolonged ingestion. In such cases, loss of appetite and weight with emaciation occurs. Paralysis and convulsions also occur. Liver and kidney cell damage occur and sometimes brain cell damage can be detected. Storage of CHI in the body fat is a constant feature but there is no relationship between the amount of storage and the degree of poisoning.

As noted above, the mode of action in poisoning is not understood, but it is obvious from the clinical picture that nerve conduction is impaired with repetitive firing from a single stimulus.
Treatment - There is no specific antidote for CHI intoxication. If the material is ingested, prompt vomiting should be induced. The physician should carry out gastric lavage. Saline laxatives (not oil laxatives) may also be given. If there is skin contact, the contaminated clothing should be removed and the skin thoroughly cleansed with soap and water. Tremors and convulsions may be controlled with barbiturates. If the patient is convulsing, a rapid acting barbiturate should be used - e.g. sodium pentothal. Sufficient barbiturate should be given to control convulsions, tremors and anxiety which may be present. Morphine and adrenaline should not be given. On empiric grounds, after apparent clinical recovery a diet low in fat and high in calcium and carbohydrate should be given.

Classification of CHI - Classification on the basis of chemical structure may be made as follows:

<table>
<thead>
<tr>
<th>Group</th>
<th>CHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>DDT</td>
</tr>
<tr>
<td></td>
<td>TDE (DDD, Rothane)</td>
</tr>
<tr>
<td></td>
<td>Perthane</td>
</tr>
<tr>
<td></td>
<td>Kelthane</td>
</tr>
<tr>
<td></td>
<td>Methoxychlor</td>
</tr>
<tr>
<td>II</td>
<td>Aldrin</td>
</tr>
<tr>
<td></td>
<td>Endrin</td>
</tr>
<tr>
<td></td>
<td>Chlordane</td>
</tr>
<tr>
<td></td>
<td>Heptachlor</td>
</tr>
<tr>
<td>III</td>
<td>BHC</td>
</tr>
<tr>
<td></td>
<td>Lindane</td>
</tr>
<tr>
<td>IV</td>
<td>Strobane</td>
</tr>
<tr>
<td></td>
<td>Toxaphene</td>
</tr>
<tr>
<td>V</td>
<td>All others such as Dilan, Chlorobenzilate</td>
</tr>
</tbody>
</table>

The oral and dermal LD 50 of CHI for the rat is given in Table IV. These were done under closely standardized conditions. There have been some reports in which it is stated that these insecticides caused purpura, blood dyscrasia, increase in hepatitis and poliomyelitis and so-called "virus-x disease". There are isolated reports and are open to question.

Comments on the health aspects of the chief chlorinated hydrocarbon insecticides are given separately below.

DDT is the prototype of this class of insecticides and millions of tons have been used since its introduction. Although it is of moderate toxicity, experience in its field use has not shown it to be hazardous. DDT in dust form does not penetrate the intact skin; in oil solution it readily penetrates the skin. Episodes of peripheral neuritis have been reported following exposure to it by direct contact. Such reports are, however, isolated. Because of the widespread use, many cases of poisoning have been reported. Most of these have resulted from accidental ingestion where the powder was mistaken for a baking ingredient or they were the result of accidental ingestion in young children. No change is produced in rats fed up to 400 ppm in the diet. Studies have shown that individuals store DDT in the body fat and that the levels stored are related to the exposure. The significance of DDT storage in body fat in humans is still open to question.
TDE (DDD, Rothane) is of low toxicity. It is unusual in that chronic feeding studies to dogs have shown that it causes atrophy of the adrenal cortex.

Perthane, Kelthane, and Metoxychlor - These are of low toxicity. For methoxychlor levels over one per cent (10,000 ppm) in the diet must be fed before evidence of toxicity is apparent.

Aldrin and Dieldrin - These insecticides are chemically related; aldrin is converted to dieldrin in the body and in soil. Both penetrate the intact skin. They should be regarded as of high to moderate toxicity and recommended precautions observed in their use. The highest level in the diet which can be fed to animals without effect is about 25 ppm. Field use with dieldrin in warm climates without protective covering or good personal hygiene has resulted in cases of poisoning. Convulsions occurred but there were no fatalities. Cases of poisoning by accidental or suicidal ingestion are known.

Chlordane and Heptachlor - These insecticides are chemically related. Heptachlor is the active principle in chlordane. The first chlordane produced was more toxic. Chronic feeding experiments showed chlordane to produce more liver cell damage than similar amounts of DDT.

Endrin and Isodrin - Endrin and isodrin are isomers but only endrin has come into insecticidal use. Endrin is the most toxic of this group. Episodes of food poisoning from contaminated flour in Great Britain and contaminated rice in Singapore have been reported. Many who ate these had convulsions but there were no deaths.

BHC and Lindane - BHC (Benzene Hexachloride) contains a mixture of isomers. This insecticide was developed in Great Britain and France at about the same time DDT was being developed in United States. Indiscriminate use of BHC by peasants in Greece is reported to have caused 79 cases of poisoning with 6 deaths. BHC is also known to produce dermatitis. Lindane is an isomer of BHC. It has a high vapour pressure and for this reason it is used in special thermal vaporizing devices. The proper precautions in the use of continuous vaporizing devices have been outlined in a code adopted by the Canadian Standards Association.

Toxaphene and Strobane - Toxaphene is a chlorinated camphene. Dogs and fish are especially sensitive to it. Strobane is a chlorinated terpene. It is of moderate toxicity.

Chlorobenzilate - This is of low toxicity.

Organic Phosphorous Insecticides

OPI are organic chemical compounds which are esters and amides of phosphoric and pyrophosphoric acid. They contain carbon, hydrogen and phosphorous in their molecules and some contain oxygen, sulphur, nitrogen and other elements. These compounds have some features in common which are listed below:

1. They are not protoplasmic poisons
2. They are miscible or slightly soluble in water
3. They are all inhibitors of the cholinesterase enzymes of the body. Some are direct inhibitors of TEPP, while others must be converted in the liver before they exert this effect e.g. parathion.

4. There is no significant tissue damage to be noted in fatal cases - either in animals or in humans.

5. These are not as persistent as the CHI and they are more chemically active.

6. They are not stored in the body tissue.

Since these compounds inhibit cholinesterase enzymes, it is possible to determine the degree of exposure by determining cholinesterase enzymes level in the blood of exposed individuals. This test is carried out regularly but does present some difficulties because the sample must be kept refrigerated until analyzed. Appendix A gives directions for submitting blood samples for cholinesterase testing. Small containers for shipment under cool conditions are easily made.

There is increasing use and importance with OPI because of the development of resistance by insects to DDT and other CHI.

Acute Poisoning with OPI - The symptoms of acute poisoning from OPI are similar in man and in animals. There is chiefly involvement of the parasympathetic nervous system with excess saliva, abdominal cramps, vomiting, diarrhoea, pin point pupils, a sense of tightness in the chest with difficulty in breathing. With involvement of other nerve fibres (preganglionic) there is headache, and increase in the heart rate. If the poisoning is severe enough, the somatic nerves are involved and irregular muscle contractions with tremors occur. Deaths which occur as a result of poisoning are as a result of respiratory failure. Pulmonary oedema may develop and present a medical emergency.

Chronic Poisoning - There is some question whether such a condition can be produced. In experimental animals, excessive secretions, increased bowel activity, general weakness and muscular twitches have been described.

The mode of action with OPI is better understood than with CHI. The OPI inhibit the cholinesterase enzyme which is responsible for removing acetyl chlorine. Acetyl chlorine acts as a chemical mediator bridge to the nerve-gland or nerve-muscle junction. If the cholinesterase enzyme is removed, acetyl chlorine is not removed and the nerve impulse carries on amounting to constant stimulation. In the case of the parasympathetic nervous system, this stimulation results in the symptoms described above.

Treatment - If the material is ingested, vomiting should be induced at once and gastric lavage carried out. If clothing and skin are splashed, the clothing should be removed at once and the skin washed with soap and water. If breathing stops, artificial resuscitation should be started at once. Oxygen therapy should be given if it is available; atropine sulphate should be given by injection intravenously, if necessary. For OPI poisoning, doses of 2 mg. (1/32gr.) should be given every 15 minutes until signs of excess atropine administration become apparent. Morphine and adrenaline should not be given. All cases of poisoning should be put at rest for 24 hours, no matter how well the patient feels after treatment. In cases which do not respond to atropine, a chemical known as 2-PAM has been used. It is commercially available. It has been used with success in serious cases of poisoning. For this reason, areas in which OPI poisoning may occur should have this material available for emergencies.
Classification of OPI - A chemical classification is more complex than with the CHI. The chemicals most likely to be encountered with their oral and dermal LD50 doses are listed in Table V. Comments on the health aspects of some of these materials are given below.

Parathion - More trouble has been experienced with parathion than with others in this group. This is not only because of the high toxicity but also because it has been in widespread use. Parathion was one of the first of this group introduced for insecticidal use. There are many reports of accidental poisoning from the field use of this material and it has received some notoriety as a method of poisoning with homicidal and suicidal intent.

TEPP - This OPI was one of the first introduced for agricultural use. It is highly toxic and readily penetrates the skin. After application, however, it is rapidly broken down and sprayed areas may be entered by workers much sooner than with parathion.

Malathion - This material is of low toxicity. It is a cholinesterase inhibitor but a weak one. Dietary levels of 5,000 ppm in the rat show no detectable effect. No cases of poisoning from its field use have been reported.

Diazinon - Diazinon is an OPI of moderate toxicity. It has come into use especially in places where insects have become resistant to the CHI.

Other OPI Materials
(1) High Toxicity: demeton (systox), di-systox, EPN, guthion, methyl parathion, sulphotepp, schradan (OMPA) phosdrin, thimet and trithion.
(2) Low Toxicity: dibrom, chlorothion, dicapthon, dipterex, dylox, and ronnel (korlan).
(3) Moderate Toxicity: co-ral, DDVP, delnav, methyl demeton (meta systox).

Some OPI compounds are described as systemics. These enter into the sprayed plant and are distributed throughout the plant becoming systemic in the true sense. A number of these compounds have been developed for systemic use in animals as well. Plant systemics include demeton (systox), meta demeton (methyl systox), schradan, phosdrin, and thimet.

Synthetic Pyrethrins

The active principles in natural pyrethrum are chemicals known as pyrethrins. Work on chemical synthesis of these led to the manufacture of allethrin, cycloethrin and furethrin. These are of low mammalian toxicity. Like pyrethrum, they are generally formulated with synergists.

Synergists

Chemicals such as n-propyl isome, piperonyl butoxide, sulphoxide, and sesamin were found to enhance the insecticidal action of the natural and synthetic pyrethrins. They are commonly used in aerosol formulations. Their toxicity to mammals is low.
**Thiocyanates**

A number of thiocyanate chemicals have been prepared synthetically as insecticides, e.g. Thanite, Lethane 384, Lethane 60 and Loro. These are of moderate to low toxicity to mammals. More toxic thiocyanates have been developed and may be put to insecticidal use.

**Carbamates**

Isolan and Sevin are examples of carbamate insecticides. Isolan is fairly toxic with an oral LD50 of about 20 mg./kg. Sevin is of low toxicity with an oral LD50 in male rats of 850 mg./kg.

**Precautions in the Use of Insecticides.**

DDT was the first of the newer synthetic insecticides and it has been in use for many years. Many have handled it without any special precautions and without difficulty. This has lulled some into a false sense of safety in the use of insecticides. Some of the newer materials require precautions in their safe use.

Sources of exposure to insecticides exist in:

1. Primary manufacture
2. Handling of bulk shipments
3. Weighing, dispensing and formulating of concentrator
4. Mixing and preparation of sprays, emulsions and dust for application
5. Application as dust, or liquid
   Application may be by ground spray equipment, aircraft or from aerosol containers.
6. Accidental contamination may occur at any stage.
7. Public exposure may come from spray drifts, contamination of food and water supplies and accidental ingestion of products sold for farm and home use.

**General Precautions.**

The precautions listed deal primarily with those engaged in application of insecticides.

1. The person handling an insecticide should know something of the risks involved.
2. There should be adequate technical and medical information with facilities to look after emergencies in case of accident.
3. Operators applying insecticides should wear impervious type head covering which should be kept clean.
4. Facilities for washing skin and clothing, in case of spills or splashes, should be available.
5. As far as possible, those exposed to insecticides should not work with them for more than 8 hours per day.
(6) Work clothing should be different from normal clothing. Coveralls serve well as work clothes.

(7) Workers should wash their hands before eating or smoking.

(8) Special care should be taken in handling concentrates - particularly in transferring concentrate from drums. Pumps should be used in place of manual pouring.

Special Precautions

It would be difficult to list in detail the precautions to be observed for each insecticide individually. The following special precautions should serve as a general guide:

CHI
(a) High to Moderate Toxicity
1. Use a hat with a wide impervious brim. This should be kept clean.
2. A shoulder cape to protect contamination of skin and shoulders has been recommended.
3. Chemically resistant gauntlet gloves should be worn in handling concentrate.
4. Coveralls should be worn in place of street clothes and laundered regularly.
5. Regular washing of the equipment with soap and water.
6. The hands should be washed before eating, smoking and before putting on gloves.
7. An 8 hour day should be the daily work maximum.

(b) Low Toxicity
1. Care should be taken in handling concentrates.

OPI
(a) High Toxicity
1. When used indoors (in green houses) complete protective clothing should be used with a respirator suitable for the material being used.
2. When used outdoors protective clothing should consist of wide-brimmed hat, shoulder cape, resistant gloves, coveralls, rubber boots, respirators where indicated.
3. Strict attention to cleanliness, both personal and equipment is important as most of these materials readily penetrate the intact skin.
4. Periodic cholinesterase testing should be carried out.

(b) Moderate Toxicity
1. Protective clothing for indoor use should include: head covering, gloves and coveralls. A suitable respirator is also recommended for those in repeated or regular exposure.
2. Strict attention to personal cleanliness is important.
3. Periodic cholinesterase testing should be carried out.
(c) **Low Toxicity**

1. Care should be taken in handling concentrates.

**Precautions for Aircraft Spraying**

1. The pilot should not assist the ground crew in handling and loading insecticide.
2. The pilot should not fly his own spray mist.
3. If OPI compounds are being used, the pilot should have periodic cholinesterase determinations.
4. If insecticides of high toxicity are being used, the pilot should wear the following: half-face respirator, goggles and clean coveralls.
5. The aircraft design and construction should be such so as to reduce contamination inside the fuselage.
6. Tanks in the aircraft should be separated from the cockpit and able to be dumped quickly by the pilot in emergencies.
7. Spraying by aircraft should not be done on windy days or near built up areas.
8. All Federal and Provincial requirements in spraying by air should be observed as well.

**References**

1. Toxicity of Pesticides
   J. M. Barnes
   Bulletin of Hygiene Vol. 34 No. 12 pp. 1205-1219 Dec. 1959

2. Toxic Hazards of Pesticides to Man - Report of a Study Group
   WHO Technical Report Series No. 114
   Geneva 1956

3. Insecticide Resistance and Vector Control - Tenth Report of the Expert Committee on Insecticides
   WHO Technical Report Series No. 191
   Geneva 1960

4. Pesticides in Relation to Public Health
   W. J. Hayes Jr.

5. Exposure to Organic Phosphorus Sprays and Occurrence of Selected Symptoms
   W. J. Hayes, Jr.; E. M. Dixon; G. J. Batchelor; and W. M. Upholt

6. Clinical Memoranda on Economic Poisons
   Communicable Disease Centre
   United States Public Health Service
   Atlanta 22, Georgia
## TABLE I
Combined Tabulation of Toxicity Classes

<table>
<thead>
<tr>
<th>Toxicity Rating</th>
<th>Commonly Used Term</th>
<th>Oral LD50 Rats mg./kg.</th>
<th>Route of Administration</th>
<th>Inhalation LC50 Concentration in ppm Causing Death in from 2 to 4 of 6 Rats Exposed for 4 Hours</th>
<th>Dermal LD50 Rabbits mg./kg.</th>
<th>Probable Lethal Dose for Man</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Extremely Toxic</td>
<td>&lt; 1</td>
<td>&lt; 10</td>
<td>&lt; 5</td>
<td>1 grain (a taste)</td>
<td>1 grain (a taste)</td>
</tr>
<tr>
<td>2</td>
<td>High Toxic</td>
<td>1-50</td>
<td>10-100</td>
<td>5-43</td>
<td>1 teaspoon (4 ml)</td>
<td>1 teaspoon (4 ml)</td>
</tr>
<tr>
<td>3</td>
<td>Moderately Toxic</td>
<td>50-500</td>
<td>100-1,000</td>
<td>44-349</td>
<td>1 ounce (30 gm)</td>
<td>1 ounce (30 gm)</td>
</tr>
<tr>
<td>4</td>
<td>Slightly Toxic</td>
<td>500-5,000</td>
<td>1,000-10,000</td>
<td>350-2,819</td>
<td>1 pint (250 gm)</td>
<td>1 pint (250 gm)</td>
</tr>
<tr>
<td>5</td>
<td>Practically Non-Toxic</td>
<td>5,000-15,000</td>
<td>10,000-100,000</td>
<td>2,820-22,599</td>
<td>1 quart</td>
<td>1 quart</td>
</tr>
<tr>
<td>6</td>
<td>Relatively Harmless</td>
<td>&gt;15,000</td>
<td>&gt;100,000</td>
<td>&gt;22,600</td>
<td>&gt;1 quart</td>
<td>&gt;1 quart</td>
</tr>
</tbody>
</table>

Source: Hodge, H. C. and Sterner, J. H.  
American Industrial Hygiene Association Quarterly  
Vol. 10, No. 4 p. 93, December 1943.
<table>
<thead>
<tr>
<th>Substance</th>
<th>Maximum Allowable Concentration in Air Mg. per Cu. M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aldrin</td>
<td>0.25</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.5</td>
</tr>
<tr>
<td>Chlordane</td>
<td>2.0</td>
</tr>
<tr>
<td>DDT</td>
<td>1.0</td>
</tr>
<tr>
<td>DDVP*</td>
<td>1.0</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>0.25</td>
</tr>
<tr>
<td>EPN</td>
<td>0.5</td>
</tr>
<tr>
<td>Fluoride</td>
<td>2.5</td>
</tr>
<tr>
<td>Lead Arsenate</td>
<td>0.15</td>
</tr>
<tr>
<td>Lindane</td>
<td>0.15</td>
</tr>
<tr>
<td>Malathion</td>
<td>15.0</td>
</tr>
<tr>
<td>Mercury (organic compounds)</td>
<td>0.01</td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>15.0</td>
</tr>
<tr>
<td>Nicotine</td>
<td>0.5</td>
</tr>
<tr>
<td>Parathion</td>
<td>0.1</td>
</tr>
<tr>
<td>Phosdrin*</td>
<td>0.1</td>
</tr>
<tr>
<td>Pyrethrum</td>
<td>2.0</td>
</tr>
<tr>
<td>Rotenone</td>
<td>5.0</td>
</tr>
<tr>
<td>Systox*</td>
<td>0.2</td>
</tr>
<tr>
<td>TEPP</td>
<td>0.05</td>
</tr>
<tr>
<td>Toxaphene</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*Tentative Values
**TABLE III**

Threshold Limit Values of Chemicals Used as Fumigants for 1960, Adopted at the Meeting of the American Conference of Governmental Industrial Hygienists.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Maximum Allowable Concentration in Air</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PPM</td>
</tr>
<tr>
<td>Carbon Tetrachloride</td>
<td>25</td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>0.1</td>
</tr>
<tr>
<td>Ethylene Dibromide</td>
<td>25</td>
</tr>
<tr>
<td>Ethylene Dichloride</td>
<td>100</td>
</tr>
<tr>
<td>Hydrogen Cyanide</td>
<td>10</td>
</tr>
<tr>
<td>Methyl Bromide</td>
<td>20</td>
</tr>
<tr>
<td>Paradichlorobenzene</td>
<td>75</td>
</tr>
</tbody>
</table>
### TABLE IV

**CHI**

Acute Oral and Dermal LD50 Values

Adult White Rats

<table>
<thead>
<tr>
<th>Compound</th>
<th>Oral LD50 (mg./kg.)</th>
<th>Dermal LD50 (mg./kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Aldrin</td>
<td>39</td>
<td>60</td>
</tr>
<tr>
<td>BHC</td>
<td>1,000</td>
<td></td>
</tr>
<tr>
<td>Chlordane</td>
<td>335</td>
<td>430</td>
</tr>
<tr>
<td>Chlorobenzilate</td>
<td>1,040</td>
<td>1,220</td>
</tr>
<tr>
<td>DDT</td>
<td>113</td>
<td>118</td>
</tr>
<tr>
<td>Dieldrin</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>Dilan</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Endrin</td>
<td>17.8</td>
<td>7.5</td>
</tr>
<tr>
<td>Heptachlor</td>
<td>100</td>
<td>162</td>
</tr>
<tr>
<td>Isodrin</td>
<td>15.5</td>
<td>7.0</td>
</tr>
<tr>
<td>Kelthane</td>
<td>1,100</td>
<td>1,000</td>
</tr>
<tr>
<td>Lindane</td>
<td>88</td>
<td>91</td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>6,000</td>
<td>-</td>
</tr>
<tr>
<td>Perthane</td>
<td>&gt;4,000</td>
<td>&gt;4,000</td>
</tr>
<tr>
<td>Strobane</td>
<td>250</td>
<td>-</td>
</tr>
<tr>
<td>TDE</td>
<td>3,000</td>
<td>-</td>
</tr>
<tr>
<td>Toxaphene</td>
<td>90</td>
<td>80</td>
</tr>
</tbody>
</table>

Source: Adapted from Clinical Memoranda on Economic Poisons
U. S. P. H. S. Communicable Disease Center 1960
<table>
<thead>
<tr>
<th>Compound</th>
<th>Oral LD50 (mg./kg.)</th>
<th>Dermal LD50 (mg./kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Chlorothion</td>
<td>880</td>
<td>980</td>
</tr>
<tr>
<td>Co-ral (90-150)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDVP</td>
<td>80</td>
<td>56</td>
</tr>
<tr>
<td>Deltav</td>
<td>43</td>
<td>23</td>
</tr>
<tr>
<td>Demeton (Systox)</td>
<td>6.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Diazinon</td>
<td>108</td>
<td>76</td>
</tr>
<tr>
<td>Dibrom (460)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dicophan</td>
<td>400</td>
<td>330</td>
</tr>
<tr>
<td>Dipterex</td>
<td>635</td>
<td>560</td>
</tr>
<tr>
<td>Di Systox</td>
<td>2.4</td>
<td>8.6</td>
</tr>
<tr>
<td>Dylox (450-500)</td>
<td></td>
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</tr>
<tr>
<td>EPN</td>
<td>36</td>
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<tr>
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<tr>
<td>Malathion</td>
<td>1,375</td>
<td>1,000</td>
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<tr>
<td>Methyl Demeton (Meta Systox)</td>
<td>(100)</td>
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<tr>
<td>Methyl Parathion</td>
<td>14</td>
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<td>Ronnel (Korlan)</td>
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<td>Schradan</td>
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<td>Triton</td>
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</table>

Source: Adapted from Clinical Memoranda on Economic Poisons
APPENDIX A

Directions for Submitting Blood Samples for Cholinesterase Testing

(1) Prepare finger by a alcohol swab.

(2) Finger prick in usual manner.

(3) Draw blood by sucking into the plastic capillary tube provided. This tube has been heparinized in the Laboratory. An ordinary rubber tube from a haemocytometer outfit can be used to suck up the blood.

(4) About five or six drops of blood are desirable to fill tube to the indicated mark (about 3/4 full).

(5) Remove rubber tube.

(6) Seal ends of the plastic tube. A cigarette lighter flame works well here to soften the ends. Pressure is applied while the plastic is molten to seal the end.

(7) Place capillary tube in container with worker's name.

(8) Put in special chilled container (35-50°F) and send by express prepaid to -

Division of Industrial Hygiene Laboratory,
360 Christie Street,
Toronto 4, Ontario.

Samples should be submitted to the Laboratory early in the week as the testing takes one day to perform.

(9) The laboratory will return your own chilled container express collect.

(10) Results will be mailed or telephoned to the physician submitting the sample as indicated by the findings.

Normal Cholinesterase Testing

<p>| | |</p>
<table>
<thead>
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<th></th>
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<tr>
<td>Plasma</td>
<td>80-200%</td>
</tr>
<tr>
<td>Red Blood Cells</td>
<td>80-120%</td>
</tr>
</tbody>
</table>

Individuals below 50% should be removed from exposure to organic phosphorus insecticides.

Results for individuals with levels under 40% will be given by telephone.

Levels of 20% of normal activity are invariably associated with symptoms of poisoning.
AIR POLLUTION

Public awareness of atmospheric pollution started at the same time as man learned to use fire. It was not until coal was used as a source of heat that the public voiced their dissatisfaction so that it can be said that air pollution became one of the social problems at the beginning of the 14th century. Activity in the field of air pollution scientific studies, effects and control has shown a steady increase in the last 60 years, and in particular since 1945. This has been caused by tremendous strides in our technological knowledge, our increase in population and the habit that humans have of trying to live together in small areas.

Smoke is historically the first air pollutant, originally it arose from the combustion of wood and constituted a nuisance. With the advent of coal the problem became more serious since the soot would soil clothing and buildings and the sulphur dioxide would offend the senses and, if present in sufficient quantities, cause damage to vegetation. However due to the lack of chemical knowledge it was not until 1600 that sulphur dioxide was recognized as a separate pollutant. Since that time we have advanced at a fairly rapid pace and can now identify a host of pollutants normally found in the urban atmosphere. However the situation is not quite as simple as it may sound, our technology is also advancing at a rapid rate, and it is estimated that some 30,000 new chemical compounds are developed annually. Why, if we know what is being used, cannot we readily identify these materials in the ambient air? Under ideal conditions such as those which exist in a factory with relatively high concentrations, this is possible but once the material is vented to the atmosphere, dilution takes place thereby reducing the concentration. Wind speed and inversion conditions have a very important bearing on the amount found and in addition chemical or photochemical reactions may take place which will change the characteristics and effects of the original pollutant.

Air pollution is an extremely complex problem covering such fields as the physical and biological sciences, engineering, public health and law. A review of the programme of the annual Air Pollution Control Association Meeting will show that the following fields are covered, agriculture, analytical methods and properties, control and sampling equipment, health, instrumentation, legislation, meteorology and public relations. It is not possible to cover all of these topics in the time allotted, however I will try and cover those items which will provide a background, stressing those facets which are of particular interest to you as Public Health Inspectors in the Province of Ontario.

PHYSICAL AND CHEMICAL ASPECTS

Some fraction of each component of the enormous number of raw materials and products of industrial and public activities finds its way into the atmosphere as an air contaminant. Gases and vapours thus released may be present in concentrations of a few parts per million or in concentrations as low as one part per billion. The toxicity to living matter of some compounds
in the parts per billion range may be greater than others which are present in concentrations that are a 1000 times greater. Aerosols usually range from 100 μg/M^3 in relatively clean air to over 500μg/M^3 for urban areas of high pollution. During periods of prolonged inversions or adverse meteorological conditions the concentrations may rise to 1000μg/M^3 or more.

Air contaminants may be divided into two classifications -

(1) airborne particulates consisting of solid and liquid particles of a wide range of sizes varying from relatively large particles over 20μ in diameter to aerosols or suspensions of fine particles extending into the submicron region, down to less than 0.05μ, and

(2) gases or vapours including the permanent gases and those compounds that have boiling points below about 200 °C.

Even though approximately 100 specific substances have been identified as contaminants arising from man's activities, there are many more that are still unknown. The particulate portion contains more than 20 metallic elements determined by spectrographic analysis of the inorganic fraction. The organic fraction is even more complex containing large numbers of aliphatic and aromatic hydrocarbons, acids, bases, phenols and a host of other types of compounds. In addition, new products are known to be created by the interaction of contaminants with each other after their discharge into the atmosphere. These mechanisms include photochemical and free radical reactions, oxidation and reduction, polymerization, condensation catalysis and others.

Classification of particulates in the air is usually made according to particle size into dustfall (deposited matter) and finely divided, suspended matter (aerosols).

Fog, mist or cloud consists of liquid particles which are mainly water if they are of natural origin. Fume is formed by high temperature volatilization or by chemical reaction. Dust is a general term usually applied to solid particles only, such as those generated from mechanical operations and disintegration of material. Smoke is produced during combustion or destructive distillation and may contain either solid or liquid particles.

The size of the particulate matter is important with regard to its inhala-

bility and retention in the human lung. Particles larger than about 5μ are usually excluded by the nasal passages. Below 5μ in diameter penetration into the lung increases rapidly but when the size becomes less than 1μ retention in the lung begins to decrease. Very small particles less than 0.5μ penetrate readily but only a small fraction is retained.

Dustfall, the term applied to that material which settles out of the atmo-

sphere is a valuable indication of the fly ash and dust deposited from stack emissions. The results are expressed in Tons per square mile per month and serve to indicate sources and areas of high and low pollution. Particle size collected in this manner is usually larger than 20-40μ. Table I indicates the range of values that are found in some cities and towns in Ontario, as well as representative values for some cities in the United States and England.
Suspended particulate, consists of small particles which are usually less than 1μ in size. They are readily transported by the wind and in the small sizes behave almost like gas molecules. The usual method of collection is filtration through a paper tape. Collected suspended particulate matter leaves a stain on the paper tape which is evaluated by means of light transmission or reflectance. These values are empirically related and reported as Coh values, coefficient of haze. The variation in Coh values may be closely related to meteorological conditions and human habits. Observations in many cities indicate a daily cycle with a diurnal rhythm, one maximum occurring around 8:00 - 9:00 o'clock and the other late in the afternoon or evening. This is illustrated in Figures 1 and 1A for Toronto at College and Elizabeth Streets.

One of the most useful methods of measuring particulate air pollution levels, is the high volume air sampler. This machine draws air at an average rate of 45-50 CFM through an 8"x 10" fiber glass filter paper. The paper is weighed before and after use and the weight of the material collected is reported in μg/M³ of air sampled. The openings through which the air is drawn are such that particulates up to 100μ in size are collected. This sampler then collects both particulate which would normally remain suspended and those that would normally be deposited.

Normally high volume air sampling particulate matter is used to determine the chemical composition of the air pollution. More than 20 metallic elements have been found by chemical and spectographic analysis, the more abundant of these are silicon, calcium, sodium, aluminum and iron. Relatively high concentrations of magnesium, lead, copper, zinc, and manganese are also evident. The type of industries in the area and the effectiveness of their control measures will influence the concentration of the elements found. Generally speaking the concentration of lead found can be correlated to the density of vehicular traffic.

Table II shows the minimum, maximum and average concentration of suspended particulate as determined by the U.S. National Air Sampling Network. A recent survey conducted along the Niagara River gave the results shown on the last line of the table. The complete results of this survey will be published shortly.

The organic constituents of air pollution have been receiving a great deal of attention lately due to their importance from a health standpoint, especially the aromatic hydrocarbons that are potent carcinogens. Condensed polycyclic aromatic compounds in the organic fraction of the urban atmosphere, in particular the benzo-pyrenes have been associated with the increased incidence of lung cancer. The presence of carcinogens in urban air have been reported in Great Britain, the U.S.A., Canada and elsewhere. Table III indicates the values found, as well as some preliminary data from a survey currently underway in Ontario.

Sulphur dioxide is the most common gaseous contaminant encountered and it has been studied extensively in many urban and industrial areas. The measurement of concentration levels and the study of dispersion of smoke and sulphur dioxide have been conducted for many years on a country-wide basis in Great Britain. These studies probably constitute the most comprehensive information available on the nature of the association between air pollution and fog to form smog.

Sulphur dioxide is readily absorbed by vegetation, soil and water surfaces and accelerates corrosion and deterioration of metals, paper, textiles and building materials.
The combustion of coal and oil are the primary sources of sulphur dioxide in urban atmospheres, while in rural areas the main source is usually the roasting and smelting of sulfide bearing ores and the production of sulphuric acid.

Hydrogen sulfide and mercaptans are not normally encountered in appreciable quantities in city atmospheres. They are normally released by such industrial operations as the manufacture of coke, distillation of tar, petroleum and natural gas processing, manufacture of viscose rayon and in certain chemical processes. These gaseous compounds can be detected by smell in the range of 0.035-0.10 ppm and will give rise to numerous complaints. Limited observations in some cities have shown that they are present in relatively low concentrations, less than 0.10 ppm.

Fluorides may be present in the atmosphere in gaseous or solid forms as emissions from the aluminum industry, from the manufacture of phosphate fertilizer, phosphoric acid, brick and tile, and ferro-enamel works. Small amounts are also liberated in the burning of coal, and from fluxing agents used in the iron and steel industry. Hydrogen fluoride and volatile fluorides are important air pollutants affecting susceptible vegetation in concentrations as low as 0.02 ppm. Normally sources of fluorides are not present in cities in numbers sufficient to raise the atmospheric level to where it will cause damage. With the recent increase of phosphate fertilizer manufacture in Ontario, fluorides are attaining a more important role in air pollution with respect to vegetation injury.

Oxides of Nitrogen are also becoming a more important cause of vegetation injury. Recent work indicates that oxides of nitrogen may be the cause of retarded growth in pine trees. It has also been shown that they play an important role in the photochemical reaction which causes smog in the Los Angeles area. Nitric oxide and peroxide are more injurious than carbon monoxide in equivalent volumes with regard to human health. Fortunately they have not been found in our urban atmosphere in sufficient concentration to affect humans. The sources of oxides of nitrogen are many, trucks, automobiles, domestic and industrial furnaces and many chemical processes.

METEOROLOGY IN AIR POLLUTION

The atmosphere is the medium in which air pollution is transported from its source. The actions of the atmosphere govern the length of time, the frequency and the concentrations to which any receptor will be exposed. However meteorology plays only a limited role in the control or elimination of air pollution since it does not affect the source strength of the pollutants emitted, and since the fundamental atmospheric processes which govern the dispersion of pollutants are not subject to control. The ultimate elimination of air pollution is through control of the sources, however the degree of control required for any given source in a given area is a direct function of the meteorological conditions which exist in the area.

Normally the data collected by weather bureaus includes wind speed and direction, which is useful in determining the gross effects, however other critical data such as turbulence, inversion frequency and strength and in the case of the area bounding the Great Lakes the occurrence of on-shore breezes and their penetration inland are not determined.
Local winds may differ markedly from the general air flow that characterizes the region. Along the shores of the Great Lakes the temperature differential between the land and water is sufficient to establish local circulations from the water to the land during the day and from the land to the water during the night. The effect is more pronounced during the summer months and is a major factor in locating industry along the shore of the Lakes. Figure 2 is a schematic illustration of this phenomenon. The plume moves inland with very little dilution until it intersects the lower convective layer. At this point the pollution is carried down to ground level as a typical fumigation.

In addition to the local shore breeze special conditions usually prevail in valleys which are fairly narrow. During the daytime the characteristic wind pattern is up the valley and up the slopes due to solar heating while just at sunset the wind reverses and the flow is down the slopes and into the valley.

An inversion is a condition which is the reverse of that which normally exists. Normally the temperature decreases with altitude at the rate of 5°F per 1000 ft. This allows the warmer air at the earth's surface to carry the pollution upwards and disperse. When the temperature is warmer aloft than at the earth's surface this air movement cannot take place and the pollution cannot disperse. This condition is known as a temperature inversion.

When the movement of the air stagnates, periods of low wind speeds (5 mph), or inversion conditions exist, the ability of the atmosphere to dilute and disperse is limited and we experience high levels of pollution. The frequency of the occurrence of these two phenomena are extremely important in control work. The Toronto Grey Cup Fog is an example of the pollution build-up under these conditions. Table IV shows daily results for one sampling site in Toronto for the 7-day period. Also shown are the averages for the smog period and for an 18-month period less the smog results. In addition, the averages for the Provincial Air Sampling Network for 18 months, less the smog period are shown.

Taking the 18 months Toronto average as a base, the concentration during the smog period increased by a factor of 3.7 for particulates, 17 for pyrene, 13 for Fluoranthrene, 8.8 for 1, 2 benzpyrene and 7 for 3, 4 benzpyrene.

AIR POLLUTION AND AGRICULTURE

There are three principal air pollutants of major interest to agriculture - sulphur dioxide, fluorine compounds and smog - the latter is a complex mixture, only partially understood at this time. There are at least two distinct types of smog, the London type, which is a mixture of coal smoke and fog with enough SO2 to impart reducing properties to the mixture - the other type is a mixture of ozone and peroxidized organic compounds formed by photochemical reactions between oxides of nitrogen and innocuous organic compounds, such as gasoline vapours or partially burned fuel. In addition to the two types of smoke certain organic compounds, such as ethylene, DDT and some heterocyclic bases have caused considerable plant damage in some locations.

SULPHUR DIOXIDE

The effects of sulphur dioxide on plants are fairly well understood. The gas is absorbed into the leaves through the stomata. Toxicity is due largely to the reducing properties of the gas. A slow oxidation of sulfite to sulfate occurs in the cells.
This reduces the toxicity of the sulfite by a factor of about 30. If sulphur dioxide
is not added to the system too quickly, a rather large amount may be added before
sulfate toxicity occurs.

Sulphur dioxide injury is local. No systemic effects have been noted - while
the injured areas of the leaves never recover, the uninjured areas quickly and fully
regain their functions and new leaves develop normally.

Many lesions caused by diseases and environmental conditions more or less
resemble those caused by SO2 but have no connection with the gas.

Different species of plants vary greatly in their susceptibility to injury by
SO2. These differences seem to be due primarily to differences in the rate of ab-
sorption of the gas by their leaves. Plants with succulent leaves of high physiolog-
ical activity are generally sensitive - examples: alfalfa, the grains, squash, cotton,
grapes, etc. An exception is corn, which keeps its stomata tightly closed a great
deal of the time.

High light intensity (especially in the morning hours), high relative humidity,
adequate moisture supply and moderate temperatures cause the stomata to open and
hence render the plant more susceptible to SO2 injury. Most plants close their stoma-
ata at night and therefore are much more resistant in the dark. Stomata also close
under conditions of moisture stress, which explains the relationship between mois-
ture and susceptibility.

Susceptibility falls off in the afternoon of cloudless days while the light inten-
sity is still high and all other conditions remain the same. It is thought that the build
up of carbohydrates in the leaf reduces the susceptibility by aldehyde-sulfite reac-
tions.

Many studies have shown that for sulphur dioxide and a number of field crops,
the reduction in yield is proportional to the percentage of leaf area destroyed.

ALFALFA

The effects of multiple fumigations are additive. A given percentage of leaf
destruction reduces the yield by the same amount regardless of the stage of growth,
even though, for example, 3 times as much leaf tissue is destroyed when the crop is
3/4 grown as when 1/4 grown.

FLUORIDES

Fluorides in general and gaseous fluorides in particular have assumed great
importance during the past decade because hydrogen fluoride and silicon tetrafluor-
ide are toxic to some plants in concentrations as low as 0.1 pptm and, secondly, be-
cause all fluorides, particulate as well as gaseous may be accumulated by forage to
build up concentrations in excess of 30-50 ppm. on the inside and outside of the leaves.
No lesions are ordinarily observed in forage. This vegetation when consumed by
cattle or sheep can cause fluorosis.

The toxic effects of fluorides have many paradoxes. Some plants are injured
by extremely low concentrations in the air and/or in the tissue while others can with-
stand more than 100-fold as much.
Fluoride is generally present in the soil to the extent of several hundred parts per million, but plants show little tendency to take it up due to its insolubility and because the fine roots have an effective mechanism for excluding it especially if the pH of the soil is high. Sodium fluoride is taken up rather readily but, of course, is rarely present. Therefore, when a plant contains more than a few ppm fluoride, atmospheric contamination is indicated. Of course there are exceptions and one is the camellia which took up 1500-2000 ppm while peach took up 20 ppm.

SMOG

London Smog - vegetation damage is generally believed to be caused by the high SO₂ levels (1.34 ppm) however some of the symptoms described are more characteristic of other pollutants such as ethylene.

Los Angeles - the pollution in this area arises largely from photochemical reactions between oxides of nitrogen and organic vapours.

The phytotoxicity of this smog is very striking particularly on spinach, romaine, endive, table beets, Swiss chard and celery. First there is a silvery or bronzing of the lower epidermis due to collapse of the sub-epidermal cells. Later the injury may extend through the leaf giving white or spotted collapsed areas on the upper leaf.

OZONE

Injury due to ozone is quite different from typical smog damage. The lesions are usually confined to the upper surface and may take the form of uniformly distributed white or brown flecks or stipples or irregularly distributed blotches.

In Ontario the tobacco fleck problem in the Delhi area is our only indication of ozone damage. In this case the symptoms occur suddenly as small scattered necrotic lesions or dark brown to black spots on the upper surface of the leaf. The injury appears first on the lower, mature leaves but may progress upward from the bottom to the top of the plant. Usually tobacco leaves are not susceptible to weather fleck until they have matured or reached the full expanded state.

During July flecking usually occurred following days when the ozone level had risen to about 5 to 7 ppm. During August flecking was observed to follow days when the ozone level rose no higher than 3 to 5 ppm. After this indication of increased susceptibility the plants became more resistant as the growing season advanced. Thus in September, when comparatively high ozone levels occurred and persisted for more than one day, the flecking following the second days fumigation was much lighter than expected.

EFFECTS ON HUMAN HEALTH

The acute effects of air pollution on human health are well known and have been extensively investigated. The outbreak in the Meuse Valley of Belgium in 1930, the City of Donora, Pennsylvania in 1948 and the London, England, episodes in December 1952 and 1962 are the classic examples that have been quoted. Many theories have been advanced as to the causal agent or agents but to date it has been impossible to show a direct cause and effect relationship for any of the pollutants found.
In all four of these episodes it was noted that illness (respiratory tract complaints) affected persons of all ages and both sexes. Those that died were predominately the elderly and those with chronic disease of the heart or of the lungs. The following tables show this quite clearly (Tables V and VI). The number of deaths resulting from the 1962 London episode were considerably less than in 1952, and this is attributed to a more stringent control programme which was instituted after the 1952 episode.

The chronic effects of air pollution have been documented in much the same way, however this is a more difficult task due to many variable factors which must be accounted for if the statistical evidence is to be valid. Studies have shown that a long continued exposure to air pollutants is associated with an increase in the frequency and severity of chronic lung disease in areas of greater air pollution. One of the classics is the case of Britons who emigrated to South Africa and New Zealand. These people who had lived in an area of high air pollution went to live in an area of relatively low air pollution. A significantly greater number of the immigrants died of lung cancer than those native to the area. This is certainly an association; is it cause and effect? On a scientific basis, this does not constitute proof.

A review of the literature reveals several facts. First, air pollution plays an important role in the etiology of lung cancer as well as many other chronic respiratory diseases. This is based on statistical studies. The second fact is that experimental medicine has not developed as yet more than an early approach to the understanding of the first fact.

Let us state this another way, we know that air pollution can be a hazard to health but we can only crudely estimate the severity of its effects and we can not explain the mechanisms involved. The medical profession finds itself in much the same position as it did in the 1920's and 1930's as regards tuberculosis. The treatment at that time was highly unsatisfactory and the real control consisted of prevention. While it is imperative that health studies be carried on so that eventually we may understand the cause and effect relationship, the immediate action is the prevention of air pollution.

**ROLES OF PROVINCE AND MUNICIPALITIES**

Within the last few months air pollution control has come to the fore at the municipal level. Any of you who live in the area of Niagara Falls through to Oshawa have undoubtedly read news releases and editorials in your local papers concerning the need for provincial control. In other areas of the Province the residents have been complaining to their municipal councils of air pollution nuisances. There must be a reason for this apparent sudden increase in public awareness. As far as the public is concerned, it would appear that as our municipalities increase in size, our industrial complexes expand and our standard of living rises, people become more aware of the aesthetic values and stimulated their interest in the effect on health.

In order to understand the reaction of the municipal councils it is necessary to review the course of events over the past 6 years or so. In 1957 the Select Committee on Air Pollution and Smoke Control submitted their report to the Legislature. In 1958 The Air Pollution Control Act was passed and the Air Pollution Control Division formed. The Act delegated to the municipalities the control of all types of air pollution from all sources. The Province was to act purely in an advisory capacity, providing assistance to the municipalities and carry out investigations into air pollution problems. Between 1958 and 1962 approximately 20 municipalities passed
by-laws under the Act and enforced them in widely varying degrees. It is interesting to note that Windsor, Hamilton and Metropolitan Toronto all had by-laws passed under The Municipal Act, which permitted them to control only the products of combustion (smoke), have not seen fit to rewrite their by-laws to control all types of air pollution.

One of the provisions of the Air Pollution Control Act was that control of air pollutants other than the products of combustion did not become effective until 2 years after the passing of the by-law. This provision was made so that industry would have time to study their problems and develop an efficient control programme.

As mentioned previously there was a wide degree of enforcement and inquiry of the officials concerned revealed several vary interesting and valid reasons. While they may be expressed in many different ways the reasons are essentially as follows:

We do not have, nor can we afford, the technical and professional staff to deal with this problem on a municipal level.

Even if we could afford the staff, there is a great scarcity of such qualified personnel in Canada and we cannot obtain them. If we could get them, we cannot offer them a promising enough future to keep them.

Why should we impose restrictions on our industry when adjoining municipalities do not? This imposes an economic disadvantage on the industry and does not solve the problem because pollution is not restricted by municipal boundaries so that even if we clean up we will be polluted by our neighbours.

It is apparent from this that the majority of municipalities felt that they were capable of administering an air pollution by-law dealing with smoke but could not cope with the complexity of emissions resulting from industrial operations.

These views were made known to the government and the Act was amended in 1963, with the Province assuming control of industrial sources of air pollution, the control of smoke remaining with the municipalities. There has been some criticism that this amendment does not go far enough and that the Province should assume control of all air pollution. At the present time, it is not practical for the Province to control smoke due to the large number of personnel involved and, of course, the expense which undoubtedly would be greater.

Regulations governing the approval of air pollution control devices for new industrial sources of air pollution or existing sources which are altered or modified are in the draft form. It is expected that this regulation will become effective in the Fall of this year. The proposed regulation will take into account the toxicity of the pollutant on human health, on vegetation, the micrometeorology of the particular area, the local topography and of course the land usage. Since the regulation is to apply to the Province as a whole, it is readily apparent that it is neither feasible or practical to apply one standard to the whole province. In essence then the regulation provides for area control.

Provision has been made in the Regulation for the testing of the air pollution control devices to ensure compliance with the approved conditions and also to ensure continued compliance.
At this time it is not intended to implement regulations governing existing industrial sources not covered above. The reason for this is purely practical, at the present time there is a dearth in Canada of people properly qualified for this type of work and the Province must, therefore, recruit and train people before the job can be undertaken. It is contemplated that it will take approximately 18 months to two years to accomplish this.

Municipalities are also experiencing difficulty in obtaining trained municipal inspectors. In order to overcome this difficulty the Province will conduct training courses at no cost to the municipality. It is the intention to provide instruction in the fundamentals which are necessary for an understanding of the problems concerned. The subjects covered will include the theory of combustion, the various types of boilers and stokers encountered, their operation and difficulties encountered. In addition the proper firing of the various types of fuels, the causes and correction of smoke emissions, and incineration will be included on the agenda. Instruction and field training in the use of smoke density charts will also be included.

Several other programmes are currently under consideration to provide assistance at little or no cost to municipalities in areas where it is not practical for the municipality to provide for itself.

The roles of the Province and the Municipality have evolved over the past six years and can be summarized as follows:

The primary function of the Province is to control air pollution arising from industrial sources. The control should be province-wide taking into account the actual pollutant emitted, the meteorology, topography and land usage in the area in question. Just as important is a programme of assistance to the municipalities to provide training for their personnel, to provide air sampling equipment for the measurement of pollution levels, and to provide analytical services. In addition the Province should investigate any problems beyond the scope of the municipalities.

A continuing programme of investigational work into the effect of air pollution on health, agriculture economic losses and the aesthetic effects is also necessary. Last but not least is provincial support of research work in the field of air pollution.

Municipalities have as their primary responsibility the control of air pollution from combustion sources. They should be prepared to assist the Province in investigational work or surveys carried out in their area and maintain an air sampling programme using equipment supplied by the Province.

So far investigational work into the effects of air pollution on health has been passed over lightly. Some idea has been given as to the complexity of such studies when health effects were discussed. The only way that such studies can be carried out is on a cooperative basis, that is, the province, the municipality and the Board of Health or Health Unit must each contribute according to their ability. The local health departments can contribute materially in these ventures and this is where the public health inspector fits into the overall picture. In any study besides knowing the air pollution levels and meteorology, a host of other information is required, necessitating the combined efforts of epidemiologists, statisticians, chemists, engineers, and physicians specializing in cardio-respiratory diseases. It is important to bear in mind that it is chronic rather than acute effects which are the primary interest in order that we will be able to set up ambient air quality criteria based on factual information.
Due to the many disciplines involved in the control of air pollution and the determination of its effects, it is absolutely necessary that all concerned cooperate whole-heartedly if an effective comprehensive programme is to be realized.
Figures and Tables

Fig. 1 - Diurnal Variation of Smoke Concentrations with Season at 67 College St., Toronto (1960 - 1963)

Fig. 1A - Monthly Variation of Smoke Concentrations at 67 College St., Toronto (1960 - 1963)

Fig. 2 - The Lake Inversion Fumigation Effect

Table I - Comparative Dustfall

Table II - Suspended Particulate, Micrograms per Cubic Meter.

Table III - Average Concentrations in Micrograms per 1000 Cubic Meters of Air

Table IV - Polycyclic Hydrocarbon Levels.

Table V - Registered Deaths in London Administrative County, by Age: Comparison of Seven-Day Period Before the 1952 Episode with the Seven-Day Period that Included the Episode.

Table VI - Number and Ratio of Deaths in London Administrative County by Selected Causes For Seven-Day Period Preceding the 1952 Episode ...
DIURNAL VARIATION OF SMOKE CONCENTRATIONS WITH SEASON
AT 67 COLLEGE ST, TORONTO (1960-1963)
MONTHLY VARIATION OF SMOKE CONCENTRATIONS
AT 67 COLLEGE ST, TORONTO (1960-1963)
The lake inversion fumigation effect.
Table I

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<td>Residential Semi-Rural</td>
<td>1955</td>
<td>35.6</td>
</tr>
<tr>
<td>Toronto</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>1956</td>
<td>85.3</td>
</tr>
<tr>
<td>Industrial Residential</td>
<td>1956</td>
<td>43.7</td>
</tr>
<tr>
<td>Residential Semi-Rural</td>
<td>1956</td>
<td>21.5</td>
</tr>
<tr>
<td>Commercial</td>
<td>1959/60/61</td>
<td>37.9</td>
</tr>
<tr>
<td>Chicago</td>
<td>1947</td>
<td>75.0</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>1951</td>
<td>56.0</td>
</tr>
<tr>
<td>Cincinnati</td>
<td>1946</td>
<td>41.6</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>1948</td>
<td>40.8</td>
</tr>
<tr>
<td>Birmingham</td>
<td>1954</td>
<td>93.2</td>
</tr>
<tr>
<td>Bristol</td>
<td>1954</td>
<td>54.9</td>
</tr>
</tbody>
</table>

Table II

SUSPENDED PARTICULATE

<table>
<thead>
<tr>
<th>Micrograms per Cubic Meter</th>
<th>Min.</th>
<th>Max.</th>
<th>Ave.</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. National Network</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Urban</td>
<td>1957/61</td>
<td>6</td>
<td>1706</td>
</tr>
<tr>
<td>Average Non-Urban</td>
<td>1957/61</td>
<td>1</td>
<td>461</td>
</tr>
<tr>
<td>Niagara River Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Urban</td>
<td>1959/60</td>
<td>34</td>
<td>288</td>
</tr>
</tbody>
</table>

Note:

U.S. average urban based on 213 stations
U.S. average non-urban based on 37 stations
Niagara average urban based on 6 stations.
### Table III

Average Concentrations in Micrograms per 1000 Cubic Meters of Air

<table>
<thead>
<tr>
<th>Country</th>
<th>Summer</th>
<th>Winter</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ontario, Canada</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 cities and towns</td>
<td>0.9</td>
<td>3.7</td>
<td>3.8</td>
<td>7.1</td>
</tr>
<tr>
<td><strong>United States</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atlanta, Birmingham, Detroit, Los Angeles, Nashville, New Orleans and San Francisco</td>
<td>1.0</td>
<td>12.6</td>
<td>2.6</td>
<td>14.3</td>
</tr>
<tr>
<td><strong>England</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mersey conurbation, 14 Localities</td>
<td>2.3</td>
<td>27.0</td>
<td>8.1</td>
<td>61.0</td>
</tr>
</tbody>
</table>

### Table IV

Polycyclic Hydrocarbon Levels

<table>
<thead>
<tr>
<th>Air Ldg'</th>
<th>Pyrene ug/1000 m³</th>
<th>Fluoranthene ug/1000 m³</th>
<th>1, 2-Benzanthanthrene ug/1000 m³</th>
<th>3, 4-Benzpyrene ug/1000 m³</th>
<th>1, 2-Benzpyrene ug/1000 m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov. 26</td>
<td>378</td>
<td>19.3</td>
<td>25.0</td>
<td>16.2</td>
<td>37.0</td>
</tr>
<tr>
<td>27</td>
<td>315</td>
<td>10.0</td>
<td>13.1</td>
<td>7.0</td>
<td>18.3</td>
</tr>
<tr>
<td>28</td>
<td>201</td>
<td>9.2</td>
<td>9.1</td>
<td>4.4</td>
<td>10.4</td>
</tr>
<tr>
<td>29</td>
<td>735</td>
<td>35.4</td>
<td>29.7</td>
<td>22.1</td>
<td>48.6</td>
</tr>
<tr>
<td>30</td>
<td>765</td>
<td>51.5</td>
<td>41.4</td>
<td>21.0</td>
<td>50.0</td>
</tr>
<tr>
<td>Dec. 3</td>
<td>720</td>
<td>18.9</td>
<td>22.2</td>
<td>15.0</td>
<td>20.6</td>
</tr>
<tr>
<td>4</td>
<td>495</td>
<td>6.6</td>
<td>7.3</td>
<td>9.3</td>
<td>16.7</td>
</tr>
</tbody>
</table>

Average ug/m³ Period

<table>
<thead>
<tr>
<th>516</th>
<th>21.6</th>
<th>21.1</th>
<th>13.6</th>
<th>28.8</th>
<th>26.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>.8 Months*</td>
<td>Toronto</td>
<td>3.0</td>
<td>3.1</td>
<td>2.5</td>
<td>7.1</td>
</tr>
<tr>
<td>.8 Months*</td>
<td>10 Stations</td>
<td>131</td>
<td>2.0</td>
<td>2.4</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Composite Samples

-110-
Table V

REGISTERED DEATHS IN LONDON ADMINISTRATIVE COUNTY, BY AGE; COMPARISON OF SEVEN-DAY PERIOD BEFORE THE 1952 EPISODE WITH THE SEVEN-DAY PERIOD THAT INCLUDED THE EPISODE

<table>
<thead>
<tr>
<th>Age</th>
<th>7-day period preceding the episode (A)</th>
<th>7-day period that included the episode (B)</th>
<th>Ratio of (B) to (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ages</td>
<td>945</td>
<td>2484</td>
<td>2.6</td>
</tr>
<tr>
<td>Under 4 weeks</td>
<td>16</td>
<td>28</td>
<td>1.8</td>
</tr>
<tr>
<td>4 weeks to 1 year</td>
<td>12</td>
<td>26</td>
<td>2.2</td>
</tr>
<tr>
<td>1-14 years</td>
<td>10</td>
<td>13</td>
<td>1.3</td>
</tr>
<tr>
<td>15-44 years</td>
<td>61</td>
<td>99</td>
<td>1.6</td>
</tr>
<tr>
<td>45-64 years</td>
<td>237</td>
<td>652</td>
<td>2.8</td>
</tr>
<tr>
<td>65-74 years</td>
<td>254</td>
<td>717</td>
<td>2.8</td>
</tr>
<tr>
<td>75 years and over</td>
<td>355</td>
<td>949</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Source: Logan (1953).

Table VI


<table>
<thead>
<tr>
<th>Cause of death</th>
<th>7 days before episode (A)</th>
<th>7 day period including period of episode (B)</th>
<th>Ratio of (B) to (A)</th>
<th>7 day period after episode (C)</th>
<th>Ratio of (C) to (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory tuberculosis</td>
<td>14</td>
<td>77</td>
<td>5.5</td>
<td>37</td>
<td>2.6</td>
</tr>
<tr>
<td>Cancer of the lung</td>
<td>45</td>
<td>69</td>
<td>1.5</td>
<td>32</td>
<td>0.7</td>
</tr>
<tr>
<td>Pneumonia (excluding those under 1 year of age)</td>
<td>45</td>
<td>168</td>
<td>3.7</td>
<td>125</td>
<td>2.8</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>76</td>
<td>704</td>
<td>9.3</td>
<td>396</td>
<td>5.2</td>
</tr>
<tr>
<td>Influenza</td>
<td>2</td>
<td>24</td>
<td>12.0</td>
<td>9</td>
<td>4.5</td>
</tr>
<tr>
<td>Other respiratory disease</td>
<td>9</td>
<td>52</td>
<td>5.8</td>
<td>21</td>
<td>2.3</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>118</td>
<td>281</td>
<td>2.4</td>
<td>152</td>
<td>1.3</td>
</tr>
<tr>
<td>Myocardial degeneration</td>
<td>88</td>
<td>244</td>
<td>2.8</td>
<td>131</td>
<td>1.5</td>
</tr>
<tr>
<td>Suicide</td>
<td>10</td>
<td>10</td>
<td>1.0</td>
<td>7</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Source: Logan (1953).
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