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THE WATER POLLUTION PROBLEM
SOURCES OF POLLUTION, TYPES AND EFFECTS OF POLLUTANTS, PREVENTION AND CONTROL

by

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WHAT IS POLLUTION?

Pollution in the simplest of terms can be defined as "too much of anything in the wrong place". For example, salt in an appropriate amount is a necessity, but too much in a stream or lake is pollution. In attempting to define pollution we are immediately brought into a major area of confusion. To different people in different areas, pollution means entirely different things.

To the health official, anything added to water that could involve a potential hazard to health, is pollution. To the out-of-door enthusiast, the fisherman, the aquatic sportsman, it is anything that interferes with swimming, boating or fishing. To the water supply official, it is anything that can make his supply unsafe or unpalatable for drinking and domestic use. We can continue this to apply to the agriculturist, the conservationist, those interested in water transportation, et cetera. However, to the average citizen, it is primarily only what he can see or smell.

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HOW DID THE PROBLEM DEVELOP?

Whether we are in Africa, Australia, Asia or America, water pollution and its causes are basically the same story retold. It is the story of people accepting gifts of water from Allah, the Taos, the Orang-Kai, the Braham, the Gods in the hills or in the heaven, depending on local religious beliefs - or merely refer to it as gifts of nature.

In their zeal to build cities, raise and process food, build and expand industries, all disposed of their wastes in the easiest and cheapest manner - usually by throwing them into the nearest watercourse. Finally, when it is discovered what sacrifices had been placed on the so-called "altar of progress" laws are passed, standards are set, governments become concerned and action is taken to reverse the typical pollution pendulum.

Then a number of variable factors begin to emerge - climate, topography, religion, economics, politics, the environmental awareness of the people, their water resources and customs. While these variables influence attitudes and government's actions, they do not alter concepts basic to water pollution problems wherever they exist.

In any developed or developing country, watercourses must serve a veritable galaxy of purposes - uses that include or could include an abundant source of protein food, transportation for commerce, aquatic recreation, sources of vital domestic water supply, irrigation for crops, water for agriculture and animals, power for the wheels of industry, a necessary industrial raw material without which there is no survival nor expansion of an industrial economy - and, yes, another important use, to absorb and transport from our "urban doorsteps" the waste products or residues of a modern urban and industrial civilization.

Wastes must be considered essentially a product of man and his activities. Such activities include industrial and technical development - increasing problems of waste production that become a major problem in developing countries. We refer to developed and developing areas. Africa, like all other continents, has examples of both.

Since the process of developing a country results in an increase of waste residue, it follows that wastes and waste production, unfortunately, have become a "symbol of civilization". However, the so-called term, "civilization" is commonly accepted as implying "responsibility and culture", but it often requires a readjustment of behaviour of each individual in a society.

In the writer's opinion, water pollution where and as it exists today, is not the result of the particular form of a government. Countries organized around central planning and control, or where the culture is based upon harmony between man and nature, or where private enterprise combines with central governments for planning and control, or where free enterprise is dominant - all have pollution problems in common. One apparent cause is technology. Numbers of people are not necessarily considered as the principal cause. One obvious conclusion is that there are not too many people per unit of space, but it is the tremendous energy and material that encompasses or surrounds each person in a developing country. It could be termed a result of so-called "quality of living" - caused by what we pass off as "technology".

POLLUTION DEFINED

How various people define pollution, the philosophical discussion of what are its causes, the multi-purpose uses of a stream and the need to keep these uses in balance - all focus attention on the necessity for the control technologists, like those in this Seminar, to have a working definition of pollution capable of being interpreted, administered and implemented. Such a definition must recognize, synthesize and make compatible these uses. A definition generally used follows:

"Water Pollution" is such alteration of the physical, thermal, chemical, biological or radioactive properties of any waters or such discharge of any contaminants into any waters as will or is likely to create a nuisance, or render such waters harmful or detrimental or injurious to public health, safety or welfare or to domestic, commercial, industrial, agricultural, recreational or other legitimate uses, or to livestock, wild animals, birds, fish or other aquatic life".

But definitions and laws are dead words until administration and implementation breathes life into them.

HOW MUCH IS TOO MUCH?

The first step in translating a definition into action is a set of criteria to establish "how much, of what causes pollution as defined". Thus, the establishment of standards, including their implementation, is the first major step to answer the question "what is the pollution problem?".

CRITERIA FOR STANDARDS

1. Need and Desirability

Standards can serve a very mutually beneficial purpose to both the control agency and the potential polluter. There is a need both by a control agency and the potential polluter that standards be adopted. They give the potential polluter a definite "measuring stick" by which to design and measure the effectiveness of its pollution control programme to prevent, abate and control its waste discharges. This need is particularly apparent where, for example, several polluters discharge effluents into the same watercourse. They give the enforcing agency a definite tool which hopefully can likewise be used by the potential polluter. It is essential, however, that all parties concerned understand the specific requirements.

2. Relevancy to Applicable Environment

It is imperative that standards be relevant to the particular environment to which they are to be applied. This includes among others, the size and nature of the receiving body of water, the general character and use of the land and water area involved. Obviously standards can and should make different provisions as required by the circumstances for different contaminant sources and for different geographical areas. Where a river, for example, has a multi-purpose use such as a source for domestic and several industrial water supplies, aquatic recreation, fishing, a waterway for commercial barge traffic, and to assimilate and transport treated wastes from urban and industrial areas, it is necessary to keep these legitimate uses in balance with each other. They should not permit the "over use" or "over protection" of any specific use.

Relevancy often requires the defining of the problem that is the basis for the particular standard.

3. Attainability

Standards must be realistic and based upon their being attainable within the state of the technical art of treatment and at a financial cost that is not truly prohibitive, otherwise standards become in fact a flat prohibition rather than a charter for prudent continuance of a desired activity and effective pollution control programme.

It must be recognized as technical people, that it is technically feasible to remove every constituent in a waste - distilled water is produced every day! However, one does not remove anything, we cannot destroy matter, and everything removed from polluting wastes must go somewhere else. Often insufficient technical considerations are given to the ultimate disposal of polluting concentrates that are removed. Also, often insufficient consideration is given to the consequences

following removal of one polluting constituent on the resultant concentration in relation to meeting other specific standards. For example, the use of lime to correct an acid discharge to meet pH standards could result in a violation of a total dissolved solids standard. There are many other possibilities.

4. Measurability

Standards must be measurable. Adherence to standards should be measurable and reliable within reason and based upon results that can be evaluated according to some pre-determined methods - mutually acceptable. Those responsible for enforcing the standards must be able to ascertain when a violation of the standard has taken place; conversely the potential polluter who desires to comply must be able to ascertain if in fact he is doing so - either in confirmation of the control agency's results and allegation or more importantly to him, often in his own defense.

Adopting a method of analysis that will serve all parties concerned and one which the individual analyst has confidence in, is of extreme importance regardless of the reasons for which the analyses are performed.

5. Progressiveness

Finally, standards must be progressive. They really are operational yardsticks which express results to be expected under certain conditions. They particularize on what conditions will prevail when the standard has been met. Standards must have a built-in, self-correcting mechanism as environmental or economic conditions change. This requires a recognition of flexibility. It must be recognized that progressiveness must fit into the pattern of relevancy to the environment, attainability and measurability.

Progress in pollution control is made by adopting standards that are relevant and attainable within the framework of current technology and reasonable economic costs and then as time, money and technology become increasingly available, the standards can be modified, and when necessary, up-graded.

The obvious alternate is to set standards to create an initial favourable public image for the control agency and immediately embark on a programme of granting variances - a procedure that usually does not produce results in environmental improvement.

INCREASING PUBLIC INTEREST

An additional factor must be recognized today. Worldwide the public is taking a more active interest in government and how governmental agencies are functioning in their interest. No country is immune from this movement.

One of the greatest changes in water pollution administration during recent years has been the awareness of and the increasing concern and knowledge of an informed public. Many of our present water pollution standards represent opinions of the technicians and scientists. To many it is becoming increasingly clear that technology is not an end in itself but a means to an end which is in the public's interest - the general public, not a selected favoured few.

Very often, we as technologists and scientists tend to forget it is the people, the public, which in the final analysis has the responsibility to decide what it considers to be in its best interests. It becomes increasingly clear and important that one of the duties of technologists and scientists in our field is to communicate knowledge to the public. Too often those involved solely in technology see their role as decision making and often even without explanation. Many of us have seen public protest in matters involving the environment often

labeled emotional or worse. It is believed the term "emotional" is often misused and especially in people's concern for their surroundings of soil, air and water - which we call our environment. In some instances, possibly the word to substitute for "emotional" is "irrational" and we cannot and must not be irrational about a subject as important as the one here today - neither the public nor the control agency.

It would seem that until any water pollution control agency and especially those persons involved in its technical aspects and the public, learn to operate in a greater understanding and harmony, much valuable time will be lost.

TYPES OF WASTES AND THEIR EFFECTS

Definitions, standards and philosophies about pollution are all important factors in control. However, their value and importance are based upon the types of wastes and their resulting pollutional effects.

These can be placed in one or more of the following categories.

1. Wastes which consume oxygen are probably the most common. These in general are organic in nature and include domestic wastes from urban areas, industrial waste from food processing industries such as canneries, dairies, packing houses textile and paper mills, distilleries and breweries, tanneries - to mention a few. The importance of their pollutional effect is emphasized by the vast amount of research and attention that has been directed toward their removal.

These degradable organic pollutants cannot only adversely affect the immediate areas of discharge, but often a wider area, dependent on the outlet watercourse. One use of a watercourse, as previously mentioned, is to assimilate wastes. A stream has this ability dependent upon the wide variety of micro-organisms which use such waste as food.

These organisms require oxygen to support life and their only source of oxygen is in the water. Harmful effects resulting from the discharge of oxygen consuming wastes not only can effect the existence of these micro-organisms, but the very existence of higher forms of aquatic life, for example fish, which require oxygen in the water.

This brief discussion related primarily to the oxygen needs for sustaining living organisms, but there are other results from oxygen consuming wastes - production of bad odours and visual nuisances. Most oxygen consuming wastes act as a pollutant in more than one of the categories discussed in this paper.

2. Waste containing particulate matter which settles out as sludge banks:

Most wastes contain some matter in suspension that can settle out when discharged to a watercourse, be it a river, lake or coastal waters. While most of the oxygen consuming wastes briefly mentioned above contain settleable solids, there are other wastes which contain inert settleable material. These include sand and silt from agricultural lands, washings from highways and streets and gravel washing operations, clays from certain industrial processes such as paper making, sludges from water softening operations, Runoff from the soil and rocks often contribute minerals that affect watercourse quality. Chlorides is one of many examples of pollution from natural sources.

While these often can produce some odours, their principal detrimental effect is to cover or blanket out and destroy the breeding and feeding places for fish and other aquatic life. Under severe conditions, such discharges could result in a watercourse becoming a "biological desert".

3. Wastes contain toxic material:

While relatively few in number, they merit consideration. These are poisonous wastes, toxic to fish and aquatic life, or which could be

harmful to humans and animals where used as a drinking water source. These originate principally from specialized industrial processes in chemical plants, plating shops, steel plants, oil refineries, paint manufacturing, etc. Also, these can be contained in land runoff from the use of pesticides and herbicides. Depending upon their particular types and concentrations, some can be minimized or their toxic effect destroyed by dilution or treatment, while some few do not lend themselves to such a solution.

Another category of toxic substances in water which are not discharged into but can naturally develop are forms of toxic algae. Certain forms in a particular portion of their life cycle can be toxic to animals and fish.

Recent emphasis has been placed on substances which are not acutely toxic but are reported to have a long term effect on the aquatic food chain. DDT is an example of such a reported material.

4. Wastes containing disease producing (pathogenic) and harmless types of bacteria:

Wastes from humans and other warm-blooded animals are the principal source of such wastes. Their effect primarily involves public health considerations in matters of drinking water supplies and especially for full body contact in aquatic recreation.

This question of the real, and especially the potential health hazard of "bacterial wastes" opens a wide area for needed research, especially in questions of viruses, their identification, bacterial multiplication and die-off. There is need for a more definitive bacterial parameter or test organism to replace what many feel is the obsolete "coliform" test.

5. Wastes visible and having obnoxious odours:

While the principal source of such wastes is domestic sewage, industrial wastes such as paunch manure from slaughtering plants, dyes and wastes from certain synthetic textile mills, tanneries, breweries and refineries are examples of others. While the pollutional effects of wastes cannot be judged solely from appearance, if all wastes were invisible, much less public attention would be directed toward water pollution control.

A guiding concept which could result in more active control - if no discharge would be permitted which would make it possible to recognize the waste from human or human activity origin.

6. Wastes which in themselves have no taste, odour or colour but which can produce pollutional effects:

Probably the most common example of such a waste is phenols which in small amounts can cause objectionable odours and tastes in treated water supplies - particularly when chlorine is used as a disinfecting agent.

Such wastes commonly result from coke quenching in steel mills and oil refineries.

Probably also the various algae nutrients of phosphorous and nitrogen contained in wastes should be included in this group.

PREVENTION, ABATEMENT AND CONTROL

Armed with the knowledge of what causes pollution and standards for its control, the key to solving the pollution problem is the agency charged with this responsibility. A water pollution control agency, regardless of its location, must exercise three basic authorities to assure a given water quality. These are prevention, abatement and control.

Prevention is exercised through approval or denial of permits establishing new or additional sources of pollution unless adequate treatment is assured. The interpretation of the word "assured" permits the agency to exercise some latitude in requiring evidences of construction, the finalization of financing, et cetera, depending upon the local attitude and conditions. This exercise of authority must be included in legislation authorizing and requiring such permits. This gives the agency a valuable "tool". Legislation is covered in a separate paper in this Seminar.

Abatement is the action taken to minimize or remove existing pollution sources. It is the most dramatic emotionally and has the greatest public appeal and lends itself to the most publicity of the three.

Assuming there is ample legislative authority to require a polluter to abate the condition he is causing, abatement action can take one of two courses: incentives to preserve and improve stream conditions through programmes based upon educational persuasive action, or the often popular delusion that the way to clean up pollution is through punitive action, but resorting to punitive action, in the writer's opinion, is an admission the control agency has failed in its job to secure abatement - there admittedly are exceptions. The best example of the failure of punitive action to secure pollution abatement is currently in the United States.

It must be stressed that any abatement action must be based upon sound technical data, the result of a practical system of surveillance, including monitoring. Abatement, unlike the other two actions, often involves economies. Technically we can produce about any quality of water we are willing and can afford to pay for.

The third is Control. It involves the constant policing and surveillance of existing treatment facilities to assure their proper operation to produce a non-pollution discharge. It is non-dramatic,

does not lend itself to publicity and public speeches, for it primarily involves day by day drudgery and time consuming effort of local control groups.

Here operator training and certification of competency become important - an important subject covered in other presentations in this Seminar. Here the plodding professional who does the work and rarely is recognized, is the important factor.

ADMINISTRATION OF CONTROL

In addition to overall philosophies, specific standards, recognition of the wastes and their pollutional effects, the basic ingredients for solving pollution problems lie within the administration of a country's specific laws.

Such administration must have an objective, principles and guiding policies, all publicly announced.

The objective of any country's national water pollution programme should be to secure and maintain the waters (both surface and ground) in such a chemical, physical and biological condition that these waters will not create a nuisance or be harmful, detrimental or injurious to public health, safety or welfare, or to the domestic, commercial, industrial, agricultural, recreational or other legitimate uses of the water, or to livestock, wild animals, birds, fish and other aquatic life. In short, the definition of pollution.

The recognition that no single standard of quality is applicable to all waters in a country and therefore no single standard for the treatment of domestic or industrial wastes, is applicable to all water pollution problems. The degree of treatment needed at a particular location on a particular watercourse must be determined by consideration of each situation. There must be the recognition of the economics involved in the treatment of wastes consistent with the use of the receiving watercourse and the area.

Relating to industry, while the ultimate object is to prevent, abate and control all industrial waste pollution, the guiding principle would be to approach the problem first through waste utilization and the recycling of water. The term "environmental residue" is perhaps psychologically preferable to the word "waste" with its implication of "loss". It symbolizes a necessary change in attitude and approach - a recognition that these residues are potentially usable products of our environment - including the use of the liquid effluent itself.

CONCLUSION

In presenting this brief discourse, it is recognized that only major phases of this broad topic could be included. It is also recognized each country participating in this Seminar has its own particular problems in pollution control - legal, historic, technical and philosophical, to mention a few. However, regardless of variables, there is one guiding principle so well expressed by one of our famous jurists when he said "a river is more than an amenity, it is a treasure that must be rationed wisely by those who have power over it".

It is further recognized that the way one country, developed or developing, controls pollution, is not necessarily the method that should be imposed on other parts of the world. It has been said that "the world is a book and who has not travelled has only read one page".

As technical people we should encourage ourselves to know other areas of the world, their customs, their religions and political and economic history, their pollution problems in the light of their economy, exchange experiences in administration, processes, materials, equipment and research. Technical co-operation "pays off" - it is a two-way street. No one person or group of persons, or a country, knows everything about pollution problems, and they do not have all the answers. There are many other technical and administrative pages in the "book of pollution control". We all can learn by "reading more than one page".

If this seminar results in a stimulation to do just that, it will have served its intended purpose.

Co-operation is not a mere sentiment but a technical and economic necessity in a world growing smaller and hopefully not more polluted each day.