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WATER, MAN, AND NATURE

Waste Aspects

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Waste Aspects

Among the words that were in the circular advertising this session was "viewpoint." So I would like to talk about viewpoint. All would agree that we want to accommodate society's water needs. Well, what are those needs and from whose viewpoint? Do we agree that we need megalopolis? Do we have to have millions and millions of people living on each other's eyebrows? Some would answer "Yes, this is important to our cultural development." Others here in the audience would answer "No!" Do we need fish in our rivers? Are we justified in spending so much of our pecuniary resources on perpetuating fish in all of our rivers? I think many would argue yes; many would argue no.

Then, on the other side of the coin, just what is an adverse impact on the environment? Adverse from the standpoint of man or fish? Shall we maintain a natural balance that is nonprejudiced so that all species have equal opportunity, or are we going to admit to being prejudiced in favor of man, and try to control the environment and even the species for his benefit?

I think that before we can sit down at a table and arrive at a meaningful, not just a euphoric, definition of the

objectives of waste treatment, we must establish a viewpoint on which we can agree, and to do this will take much "jawboning" and symposia such as this and others involving the general population. I don't want to undertake that today. But having called your attention to this difficulty, I want to address most of my remarks to my particular topic of interest - research on wastewater treatment.

To lend true perspective to our viewpoint, I must be fair by saying that research in wastewater is not new either. If one will read Jonathan Swift's Gulliver's Travels, he will see that, more than 150 years ago, Mr. Swift had a researcher at work on the heavenly island of Laputa where he tirelessly stirred sewage in huge vats in an attempt to reconstruct from it the original food. Now I think I have read some grant applications still aimed at solving that supreme challenge of waste disposal. In fact, though, about 90 percent of our wastewater pollution problems today, both municipal and industrial, can be successfully met with existing technology. What is needed to make major progress in cleaning up our environment is the will to agree upon and enforce criteria and regulations and the dollars with which to do so now. This realistic

approach can abate about 90 percent of our wastewater problems. And this can be done with existing conventional treatment processes. But how about the other ten percent?

The other ten percent, however, is an ever-increasing threat. If we look at the burgeoning population and the unequal distribution of man (not the oft quoted unequal distribution of water), we can see that, even though the recycling time for water is relatively short, the insult becomes permanent at a particular location. This is because the quantities of waste continually overwhelm the stream. At such places, and there are now many, 90 percent treatment is no longer adequate. If we take a city of five million people and say that we are achieving 90 percent removal of the waste, we still obviously are discharging a tremendous quantity of equivalent raw waste into the receiving stream. I think we are approaching the point where we can no longer talk about percentages. We must talk about the quantities of various pollutants in the waste and the ability of the streams to accept these. We are approaching the point that has long been evident with respect to atomic wastes. Even 90 percent removal doesn't mean very much. Even 99 percent doesn't mean very much. We have to apply the decimal point and begin adding 9's in a row after that.

When we talk about cities stretching from Boston to Norfolk, these are the kinds of numbers we must face in the not too distant future.

How can we develop economic processes that can clean water to this extent? Well, first we ought to tackle the problem at its municipal, industrial and agricultural sources; and try to produce less waste and pollute less of our water with it. I'd like to point out here that "wastewater" is a misnomer. Except for the times of Noah and Jamestown, there has been very little wastewater. The waste that plagues us is a relatively small quantity of material contained in the water. Water is merely the vehicle we use to carry away the waste. Can we reduce the amount of this vehicle? Are there some instances in which we might use vehicles other than water? In a typical home, we take a concentrated waste and greatly dilute it in order to transport it to a "factory" where almost all the time and effort is spent in reconcentrating it so that it can be treated. The treatment process is primarily a biological one and it will not work effectively, as any person in the fermentation industry knows, at the low concentrations of solutes, substrates, and organisms to which the sewage has been diluted merely in order to transport it. So we are in

a double ratchet: the use of perfectly good water as a waste vehicle offsets and upsets our waste treatment efforts.

Next, in developing economic treatment processes, we must carefully define the objectives. We're beginning to hear more and more talk about ecological zones, or water quality zones, or specific water quality criteria for different uses. In a major municipality today, we treat hundreds of millions of gallons of river water a day to create drinking water out of all of it. Now only a very small fraction of a percent of that water is used for drinking water. Is it really necessary to spend all of that effort and money to bring the total quantity of water up to drinking quality when we use most of it for very inferior uses? This is not a new concept, people studied the possibility of dual water supplies some time ago. There were some engineering and public health problems associated with potential cross connections between the two supplies. The drinking supply might become contaminated with the nonpotable supply. Perhaps our modern computerization and engineering techniques warrant a reexamination of that approach.

But, even after we have wisely defined our needs and conserved our water, there will still be large quantities of wastewater requiring high degrees of treatment.

I'd like to talk about some specific research approaches and particularly those that involve the biologist, because the treatment of wastewater is and, I believe, will remain largely biological. The ultimate municipal waste treatment plant is the single-celled microorganism. As an engineer, I must tell you with some chagrin that the engineers do not recognize this fact. The engineers do not know what the cell does to treat the water, nor even which cells do so. If one goes to the literature on sewage treatment, he will be unable to come away with any understanding of which specific microorganism or even which groups of microorganisms are responsible for treating the sewage in our municipal treatment plants. For more than half a century, the activated sludge process has gained increasing use in municipalities. The biological process is very poorly understood. Indeed, if one looks at the record, it was long ago reported and parroted that a single microorganism, Zooglea ramagira, was responsible for the treatment of waste. Subsequently, about 100 species of microorganisms were isolated from the process and given the credit. However, their respective roles were never established. And, more recently, it has been reported that it is not bacteria at all which are responsible for the treatment process,

but protozoa. So here we have a tremendous gap in knowledge which can only be bridged by the biologist, and I hope that the biologist - whom I now criticize with equal fervor - is ready to accept this challenge. For I remember, not many years ago, trying to talk to biologists about sewage treatment and learned it was beneath their dignity to discuss this matter. And it has only been in very recent years that one could even find the word "sewage" in our more erudite scientific journals. Now they compete to print the word, so I believe there is some hope.

What have been the tools of sewage treatment over the past years? There have been primarily three - gravity, microorganisms and sunlight, very little else. And the reason is that, until now, the engineers have provided water to our municipalities, to our industries, to our farms so cheaply, that the recipients of this bonanza cannot get into a frame of mind to spend money to dispose of the used water. The clean water has been too cheap. If you live in a municipality today, you buy, for about one cent, 200 pounds of a manufactured product, which price includes its delivery across 30 or 50 miles to your door and which price includes achieving and maintaining sterility of the product and keeping it

under pressure constantly for your use. You can't ship 200 pounds of dirt across town for a penny! Unlike other utility industries, the water industry has spoiled the public. This conditioning must be reversed now if we are going to put some pecuniary energy into treatment processes. We must augment the weapons of gravity, microorganisms and sunlight. How can we do this?

Well, one strong reaction has already set in. The chemical engineers, with a whoop and a howl, have come to the fore to state that the sanitary engineers, so long lagging in this field, should not be permitted to control it - the war is too important to be run by the generals. Indeed, they say, "we must not apply the vague, tenuous, nebulous biological treatment process, but give the stuff a good dose of chemicals. Chemicals can precipitate the heck out of anything." And they can, but at a cost which, even recognizing what a bargain you have had with water all these years, might yet be an unnecessarily large jump for the taxpayers. To take the bull by the horns with brute force and precipitate or ion exchange everything out of the sewage will probably increase the cost of wastewater treatment five to ten fold. This may be too expensive for openers into the new, more costly era that is fast approaching us. I think the answer lies in the "farmer and the cowman" trying to be friends.

The sanitary engineers, the chemical engineers and the biologists ought to take the approach that we should utilize biological treatment to the maximum extent possible. Micro-organisms are present in our waste. They are free. And, there are many things we have not done and can do to optimize their activities in purifying sewage. First, of course, we must find out which species, or group, we wish to encourage and which we wish to discourage. Then, there are things that we can do to accomplish this well within the realm of economic treatment and short of the cost of complete chemical-physical treatment. Then, if we can't reach our, say, 99.99 percent treatment goals, and we probably can't, we can call upon the wonders of the chemical engineer to finish the job. The combined biological-chemical package should certainly be more economical than going overboard with either method alone.

We are primarily biologists here. What are some of the things that biologists can contribute? First, we certainly ought to find out what the organisms are. I doubt that even the famous brewing company that advertises its gusto so widely would have much enthusiasm for operating its plant by throwing in a few shovelsful of hay, saying that, once in a while, if things go properly, this produces palatable beer. If one examines the

industrial fermentation processes, he finds they are very tightly controlled. The brewing organisms are carefully cultured, cultivated, nurtured and used, and I don't think that the situation should be one bit different in the field of sewage treatment. Once we know which organisms we wish to encourage in this process, we can examine means to do it.

Among the things we can control are the amount of oxygen and the rate at which it is pumped into the sewage. If one goes to the scientific literature, he will find that oxygen frequently limits the metabolism of aquatic microorganisms by the very nature of the fact that oxygen is so uncooperative in dissolving in water. Oxygen saturated water contains only eight or, at best, ten milligrams per liter. The engineer, on the other hand, has traditionally sought to be as niggardly as possible with supplying oxygen to the treatment process because it costs money.

Nutrients in sewage can be another factor limiting treatment. We've heard much about eutrophication caused by nutrients escaping from the sewage plant into our lakes and estuaries and causing unwanted phytoplankton population explosions in the stream. But the poor organisms in the sewage treatment plant are not always happy with the inorganic nutrients which they receive. Some critical ones are present

in suboptimal amounts. The organic substrates - the very wastes upon which the organisms feed and which we wish them to degrade - are always present in very minimal concentration for the active metabolism of the organisms by virtue of the transportation problem to which I called your attention.

The temperature is almost invariably suboptimal for the metabolism of the microorganisms in a sewage treatment plant. Yet, to my knowledge there has been little reexamination of this problem with respect to the possible use of "waste heat" from fossil fuel and nuclear power plants.

One thing that you biologists have widely reported is that microorganisms like to live on surfaces. Bottles containing equal volumes of the same water, of different shapes, support the growth of microorganisms in accordance with the surface-to-volume ratio. Unfortunately, the "bottles" built for sewage treatment are designed to produce almost minimum surface area per unit volume. There is much that can be done to improve biological treatment by controlling surface area and the materials of which it is constructed. For example, it is not hard to imagine using positively charged, finely divided materials to offer attractive surfaces for the generally negatively charged microorganisms. At the same time, these surfaces would concentrate some of the phosphates, nitrates and other negative ions which the organisms could then remove from the sewage.

Another biological phenomenon, unexplored with respect to sewage treatment, is that of biorhythm. Diurnal loading is imposed on sewage treatment plants by the rhythm of water use. But there are also strange things that occur in the treatment process diurnally in variability of the effectiveness of treatment. I just wonder if some of this might be caused by circadian biorhythms. Metabolic biorhythms have been reported extensively in the literature as occurring in macroorganisms and microorganisms alike. Might there be some effect on sewage treatment, and, if so, can we change our treatment process to take advantage of this?

Well, as Tom Lehrer would say, I have a modest example of how biological processes might be used today to improve sewage treatment. For a number of years my group has been working at the eutrophication problem by attempting to remove phosphates from sewage. We have found that we are now able to do this using the microorganisms which are present in the sewage. We can impose a modification on the activated sludge sewage treatment process whereby, as demonstrated in a series of pilot plant tests, we have sustained phosphate removals exceeding 97 percent. Now, that degree of phosphate removal will do for now in a number of areas where the eutrophication problem exists. But, in time, as the population grows, greater removals will be required.

I would suggest that the way to approach this is to squeeze this last bit of biology out of the treatment plant and, when we have to go to, say 99.99 percent removal, add the wherewithall to do that by chemical or physical treatment methods.

I'd like to conclude with my impression of where the battle against pollution is today. I don't see a very rosy picture. Sanitary engineers have tried for two generations to alert the public to its present state of alarm about the environment. They have been significantly and singularly unsuccessful, always speaking solely to the technical point at hand and not to the broader issues - and, even so, speaking in carefully conservative language, not to arouse undue alarm. They did not alert the public to its present concern for the environment. I personally think the thing which sounded the ecology claxon for this generation was the Apollo program of NASA. When we began to see exquisite pictures of Earth taken from 200,000 miles away, we saw how kind and beautiful our world really is, how thin the film of atmosphere, how frail and delicate are the myriad vital balances that sustain the planet; how the failure of any one could be fatal. When we learned of the water scarcity on the Moon (and on Mars) we began to appreciate the very rare juxtaposition of conditions that maintained the Earth in a viable condition. I think these

pictures for the first time brought home to the public the realization of our situation, that we are, in effect, on a spacecraft with very finite resources. This new awareness is what has prompted the public concern with the environmental problem and the current interest.

The Government began mirroring the public's concern as befits a democratic Government to do. But I fear that the Government's approach to solving this problem has been to attempt to reorganize it out of existence. If we follow some of the history, we see that, not long ago, the wonders in sewage treatment were being performed by the Public Health Service. Undergoing the first test of the reorganization theory, it lost its function to the then newly created Department of Health, Education, and Welfare. Here a new organization, called the Federal Water Pollution Control Administration, was created. This, in turn, was reorganized, to further solve the problem, into the Interior Department's Federal Water Quality Administration. The most recent reorganization thrust has dissolved the problem into the Environmental Protection Agency's Office of Water Quality. And now there are rumors of a new reorganization to finish the job.

There have been commissions which have studied water at great length and they have come up with the amazing conclusion that water touches pretty much on almost everything we do in our lives.

This led some to conclude that maybe what we had better do is to put all these together into one Agency which can comprehensively - that's the key word - deal with the problem and eliminate duplication. Well, the job will require the efforts of many people in many functional units, and I really am not sure that it makes much difference whether they are all under one label or not. I fear that the approach of reorganizing the problem is not going to blow it away like a pile of dust. It reminds me of General McClellan marching up and down the Potomac. Despite all his fancy preparations for combat, the General, in Lincoln's words, had "the slows" in dealing with the real issue. The Federal government still has the slows on the same Potomac which it has unsuccessfully tried to clean for half a century.

I see another trend, and that is creating a new layer of people in the reorganization game at the administrative level. We now find complex technical and scientific decisions being made at an administrative level by nontechnical persons. Administrators are being called upon to serve for very finite lengths of time at the Federal level and frequently introduce programs of a transient nature. This has the effect of forestalling true technical solutions.

Pollution control has also suffered from the relatively new technique of defunding projects. Projects start out in the Congress where funds are authorized and appropriated but we find in recent years that in the field of water pollution abatement,

and others, these funds are not being expended. They are being held up at the Bureau of the Budget level for budgetary reasons. The cost of cleaning up the waters is going to be a very real cost even if done with good economy, and, until we do open up the coffers, we are going to find it very difficult to make much progress. And now to compound the situation the President has said that we have to freeze prices because of the economic situation and many people agree. Unfortunately, I think it is a fact of life that the price freeze is going to freeze the progress of pollution control. Industry may be given tax benefits to clean up, but, tax advantages become less appealing in times of declining profits. The only person that can supply the money for the cleanup is the person who wants the cleanup - the person who funds everything in the long run anyhow - the consumer-taxpayer. When the prices of industrial products cannot accommodate the cleanup, the cleanup isn't going to come. I doubt very much whether the Government is going to find itself in a position to enforce cleanup while denying industry the power to raise the necessary funds. Similarly, as the economy suffers, taxes decline, making the public portion of the program harder to carry out. I fear, therefore, that, despite the public uproar, not very much is going to be done about the field of waste-water control, at least in the immediate period ahead. Thank you.