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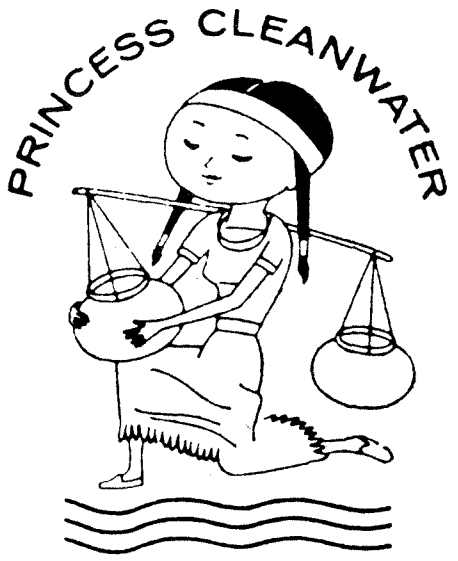

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"Unsolved Problems in Water Pollution"

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I speak not as an expert, but as a concerned layman in many of these fields. I have done a lot of reading, and I am interested in water because of my professional affiliations, but not in water pollution per se. So I am really here in a sense to give you the big picture as an informed citizen might see it by reading technical and non-technical journals. If you want to get the expert view, you should certainly listen to Bill Walton, who follows me. He is much more of an expert than I.

I am going to talk about the major unsolved problems as I see them. Chief among these, I think, is where we are going to get all the water to wash away our wastes and cleanse ourselves and feed ourselves. Although, among the planets, the earth is very well endowed with water, it is nevertheless going to run short for our own human uses within the very near future.

For instance, it has been estimated that in the 2000 A. D., the Eastern United States will need about 400 billion gallons daily. And 50% of the time, we may expect the flow in that part of the country to be at about this level. Part of the time, of course, it will be well below it. So we can foresee a crude sort of balance between uses and supplies there by the year 2000. Of course, after that the problem will get worse.

By 1980, which is less than twelve years away now, the Western United States will need about 150 billion gallons daily, and the maximum dependable flow to supply that need will be about 150 billion gallons. But half the time, it may be down around 70 billion or less. So this represents a major deficit, brought about largely by irrigation use. We are already in difficulties in the west, and are getting out of them by making overdrafts on supplies of groundwater. And, of course, this can't continue indefinitely, any more than we can keep building up our overdrafts at the bank.

Some people have looked to the future and predicted that we can get around many of our difficulties by modifying the weather. There is a distinct possibility that we can do this in the future, but we cannot at the moment; and when we do we won't be able to predict the results very easily. It is quite conceivable that by modifying the weather to improve the rain supply in the west, we might reduce it in the east, and of course, remembering the great shortage in New England a few years ago, you can see that that would raise very severe inter-state problems. We might also shift patterns of rainfall north and south, and wind up in inter-national difficulties with Canada or Mexico.

Although a major problem is the increasing per capita need of water as time goes on, this is made much more severe by the increase in population, as has just been mentioned by another speaker. And really, we can say in a general way that pollution is largely people. Pollution starts with people, and if there are too many people on the face of the earth, then people are pollution.

The major thing that we can do to lessen the pollution problem is to persuade our children not to have as many children as we had, to make sure that they bring their population problem under control as we have failed to do. And I speak as a guilty person here - I have four children, but it is often said that a reformed sinner makes the best preacher! However that may be, we do have to look on the population problem as the primary problem in pollution. There is no doubt of that whatever. It is the major problem on the face of the earth today in all respects. All our other problems go back to that as the major factor making them more difficult.

Now these days we have the capability of pollution on a really major scale. We can damage, perhaps beyond recall, even our largest lakes. It has been mentioned that Lake Erie is on the way out. It is now a giant cesspool, radically changed for the worse. I have friends who live on its shore, and they say that it is great fun to go boating, but they are always worried that they might fall in.

Lake Michigan is presently in danger. This is a much larger body of water and it has been felt that there is plenty of water in it to dilute all the sewage that Milwaukee and the major cities dump into it. But a friend of mine who has come over from Great Britain to work on Lake Michigan in recent years has recently shown that the problem is much more severe than had been imagined, because the in-shore circulation is separated in large measure from the major off-shore water mass. This means that pollution dumped into in-shore waters builds up there and isn't immediately mixed into the whole water body. Therefore, there is a much smaller water mass to dump pollution into than had been envisioned previously. So Lake Michigan is in trouble.

Lake Superior is just beginning to show signs of change. Nobody knows whether the major factor will be people, or in some parts taconite wastes. But it is not at all impossible that we can damage Lake Superior on a major scale, and Minnesota should certainly have a strong interest in developing studies there rapidly before it is too late.

Now, what are the major pollution problems besides people and the amount of water we have available to wash them in? Well, we can say that we have a major problem with urban wastes, both human and industrial, and for these we have primary and secondary sewage treatments in widespread use. This is fine, but by 1980 again, it has been estimated that the oxygen demand of treated effluents will consume the entire oxygen in a volume of water equal to the dry weather flow of all twenty-two major river systems in the United States. In some it will be more, in some it will be less, but we are going to be in deep trouble within the next decade or so.

We are already in deep trouble in other respects, even if we don't recognize it. Even if the organic matter in these wastes is entirely oxidized, so that a sewage engineer can cheerfully take a glass of the effluent and down it and say "Here's how" as a demonstration of purity, there will still remain in that water large amounts of nitrates and phosphates. These are mineral salts whose removal is extremely expensive, and they will pollute our rivers and lakes by promoting large

growths of noxious blue-green algae. Some of these algae, as you may know, produce toxins which have been fatal to domestic animals, although I don't know of any cases of human fatality.

Blooms of blue-green algae are becoming increasingly serious in Minnesota lakes around the Twin Cities, as we see all the time, because we are out there working on them. The algae are very much on the increase, and at the moment all we can do is to dump in copper sulfate or other weed killers to try to hold them down. But this poses all sorts of long-term problems for which we have no answers at the present time. We don't know the long-term consequence of continued treatment of this kind. We need to know a great deal more about the basic ecology of the blue-green algae and about the bacteria in our natural waters before we can even begin to understand what is going on and what will happen as our problems grow worse. We don't know enough about what happens in a natural lake concerning the nutrient cycles and the biological cycles yet. We know far less about what those cycles will be like when they are interfered with by large amounts of waste of one kind or another. So we need a great deal of basic research before the applied research can even get moving on a really well-developed scale.

Another of the major problems for which we have no terminal solution is agricultural drainage. Now fertilizers, especially nitrogen and phosphorus, are employed to enrich soils, partly because we have mined out the nitrogen and the phosphorus that was there in the original prairie when we opened the prairie up for cultivation. We can't help this. So we add the fertilizers necessary to produce big crops to meet our expanding population, but the plants aren't very effective in taking up these fertilizers. Because of this, large amounts of nutrient salts are washed into our ground and stream waters and into the lakes. Big Stone Lake has been mentioned as a problem in Minnesota - it is partly a fertilizer problem, but also partly a problem of feedlots around the margin, I understand. Unfortunately, the fertilizer that gets into our waterways is much too dispersed for practicable and economical removal. On some watersheds, agricultural nitrogen and phosphorus may be equal to or more significant than urban waste in polluting our waters, and the agricultural pollution may be much more difficult to deal with on the large scale that is necessary.

Just to give you some figures that have been estimated for discharge of nitrogen and phosphorus to streams and rivers, in millions of pounds per year: In 1900, it was estimated that nitrogen discharge was about 200 million pounds per year. By 1963, it had gone up six-fold. By the year 2000, it has been estimated that there will have been a ten-fold increase within one hundred years. A rather major change, a whole order of magnitude. For phosphorus, the estimate in 1900 was about 10 million pounds per year. In 1940, it had gone up to 30 million pounds, in 1963 it had risen to 250 million pounds, and it is expected that in the year 2000 it will be up to 500 million pounds, a fifty-fold increase in a hundred years.

This recent dramatic rise of phosphorus one of the major limiting nutrients for blue-green algae, in our waters is owing to the general use of detergents in place of soap. These detergents have phosphate builders, as they are called, in them which are a really serious pollution problem. This I gather is true whether

the detergents are "hard" or "soft". The "hard" detergents pose one kind of problem. They are not easily broken down by bacteria, i.e., they are not biodegradable, and therefore they create foaming problems in sewage plants, and in rivers and lakes. The industry has therefore been forced to develop so-called "soft" detergents which can be easily broken down and degraded by bacteria. This gets rid of the foaming problem, but it immediately favors bacterial and other growths in our waterways and contributes to the tremendous oxygen demand on our rivers and streams and lakes. So we get rid of one problem and in the process we increase another.

A further major problem is that of pesticides, about which you are all well-informed by reading the pros and cons on Rachel Carson's "Silent Spring". I happen to be on Rachel Carson's side in this issue. You will find other members of the University who are on the other side; but I don't think that Rachel Carson was advocating that we do away with pesticides, she was advocating a closer look at their rational use, and pointing out the dangers if we fail to take this closer look. Pesticides have a number of problems associated with their use. Some are cumulative in the soil, chlorinated hydrocarbons especially. They concentrate along food chains so that from less than a part per million in the water from agricultural drainage, one may get hundreds of parts per million in the fish or thousands of parts per million in the birds eating the fish. In this way some pesticides may reach toxic levels, or at least levels which reduce fertility. We may in fact solve our population problem partly by poisoning our own fertility. This is one way out, but not - I think - one that we would choose!

We know there is strong evidence that pesticides have been responsible for killing millions of fish in the '60's throughout the Lower Mississippi and the Delta. There are numerous cases from many states in the union, I am sure, in which pesticides may be implicated; although it is just as difficult to tie this down as it is to tie together completely smoking and deaths from lung cancer. Many of us believe in it, although the evidence is circumstantial. Pesticides are broad-spectrum killers, on the whole, and they are toxic to a wide range of organisms, including man. And we really have no knowledge, no knowledge at all, of the effects of a lifetime exposure to very low dose rates. This is a problem that has come up within our lifetimes, just as it has come up with radio-active fallout. And we don't know in the case of pesticides whether there is a threshhold of concentration below which we are entirely safe, or whether some of these substances are mutagenic - producing hereditary defects in whatever dose we accept - we just don't know enough about it.

Organisms adapt to pesticides, as we all know, and this means that we are continually forced to escalate our chemical warfare to more toxic levels. And of course, if they are more toxic to the organisms, they are more toxic to us too. These things also have unsuspected side effects which suddenly turn up in the most odd ways. One of the more interesting of these, I think, is an effect that was observed in a Bolivian village which decided to use DDT for malaria control, as is widely practiced and quite rightly so. Well, the side effect in this case was that they happened to kill off the village cats at the same time. The village was invaded by small mouse-like mammals which, it turned out, harbored a dangerous virus.

It is said that more than 300 villagers died of this particular plague before the situation was restored. These sorts of things are continually a danger to us if we don't - by taxing the profits of the agricultural chemical industry - put more money into research on the effects, the long-term effects on food-chain concentrations, of all the substances we so gaily utilize without understanding their dangers to human society over the long term. We must take the utmost care in using such pesticides, and we must search for much more specific controls for pests. These are usually biological rather than chemical controls.

We also have problems of radio-active pollution from many sources, including accidental reactor releases. I happened to live near the Windscale plutonium factory when it caught on fire in 1958, and the fallout release was said later to have been roughly equivalent to that from a Hiroshima-type bomb. It was mainly of radioactive iodine, of which we knew very little at the time. We now know a lot more as a consequence of this particular accident. I happen to be concerned about the problem of siting a reactor - a major reactor - at Monticello upstream of our water supply and in a tornado zone. There is a great deal of argument about whether we should accept the small, but nevertheless finite, possibility of a major accident in a site like this. I happen to think that we should look for other choices, but other people will argue quite differently and their arguments should also be listened to.

We also have problems with normal reactor effluents - such as radioactive iodine and ruthenium. Lately there has been a good deal of concern expressed about the possible danger of radioactive krypton, a noble gas which hadn't been felt to be a serious problem, but which some people now believe might be one of the major problems if we go to very large scale reactor development. Again, we just don't know enough about the answers to predict the future. But we have real problems with the future of radio-active waste disposal, because sooner or later we have got to face the difficulty of how we are going to hold all this highly radioactive material from spent fuel elements and so on, and how we can reprocess materials in a safe condition. We can bury some of our wastes in salt mines, which are very dry, so that they won't get into the ground water; we can bake some of these things into ceramic bricks, which won't weather enough to allow radioactive material to get out before the radio-activity is decayed; but we are still faced with very serious problems if we are to develop a high-level reactor technology. Even spoil heaps from uranium mining have caused problems, and ones which will be with us for a long time.

We have all sorts of other mining problems too, among them those of ore concentration, and whether taconite wastes are going to pollute Lake Superior to any serious degree. Again, we just don't know. I don't know a single limnologist who could give you a conclusive answer to that question. If we put in an ore-concentrating plant near Ely and start dumping the water from the settling basins into the Kawishawi River system, there might be one chemist in the United States who could make a guess at the concentrations of copper and nickel you might find downstream. I don't know any biologist who would be willing at this moment to predict the possible effects of such a development. Smelting, of course, is a much more serious problem, because this sends sulfur dioxide and heavy metals up the

chimney. Such effluents pollute the surrounding waters very seriously in places like Sudbury. I have worked a great deal there, and it really is a sort of mountains-of-the-moon landscape with very serious problems of revegetation. The forest damage poses a very serious fire threat as well.

Paper mills and pulp mills are another source of problems which I don't want to discuss at all, but which are in Minnesota.

Really, in the over-all matter of pollution, we are suffering from a problem of attitude. Many of us, like G. K. Chesterton, don't care where the water goes if it doesn't get into the wine, and we just don't think about the water that we flush down the toilet or wash down the sink and of the fact that somebody else is going to have to use it downstream. This attitude is responsible for the misuse of natural resources which leads to pollution.

The problem is, in essence, one of cycling wastes back to resources again. Today's resources are, in fact, tomorrow's garbage, but tomorrow's garbage is the resource for the day after. We have a synonymy here between wastes and resources, and we must treat wastes as resources if we are to bring our natural world into balance. Eventually the biological wastes or garbage we put out are remade by plants into resources for animals with the aid of sunlight, and with the oxygen we breathe as a useful by-products. We are, therefore, not consumers - we are users; and we should pass the materials that we have used on in a form suitable for reuse.

In advanced societies, as in primitive ones, the emphasis is still placed on the extraction and use of resources. Very little attention is given to the disposal of wastes, and even less consideration is given to the conversion of wastes back to resources again. Therefore, garbage piles up and becomes pollution, which is, in fact, a deflected resource. All the sinks or dumps into which we pile our wastes are finite, and like cesspools, they become septic when we overload them. Lake Erie is a case in point, Lake Michigan may be on the way. I would hazard as a general rule or a general prophecy that the limiting reaction for the advancement of human society, as we know it, may well be this process of converting garbage or waste back into resources, and this means water as well as solid waste. We should collect waste as close to the source as possible, and if we can't deal with it, we should store it for later and more efficient processes of reuse. Our processes of extraction and manufacture should, therefore, be designed or redesigned with a view to reuse rather than to dumping. In this way, our use of resources will be optimized and we shall at the same time prevent many of the problems of pollution before they occur.

Our best possible chance to try out such procedures would be in the proposed experimental cities which have been advocated by Athelstan Spilhaus here in Minnesota, since we can't test such processes readily or adequately in our present inefficient and very antiquated cities. We shall need the equivalent of several new cities to handle the expanding population we will have by the end of the century. Why not make them centers of experiment and new design? If we do, we should plan our sewage and waste disposal and conversion on a regional basis of whole watershed planning, and this may include not only metropolitan areas, but groups of states.

Even for our present cities, such planning is necessary, and can be effective. This has been shown by experience in the Ruhr region in Germany, which is one of the most heavily industrialized areas in the world. In the waterways of the Ruhr a great deal of the shoreline is suitable for swimming and other recreational use, and I have read that prices of unsubsidized public water supply are as low or lower than they are in other urban areas of Germany which have not made the same efforts to keep their environments clean.

Pollution is really a hidden cost of technology. By making treatment and prevention part of the manufacturing cost and part of the extraction cost, possibilities of reuse will be stimulated. We can start right here on the Mississippi and on the 10,000 lakes of which we boast so proudly. It is not really too late, I hope, for us to see them cleaned up in our lifetime!