Discussion Paper

THE DIMENSIONS OF INTERNATIONAL POLLUTION

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Abstract

The main characteristics of international pollution are examined as a basis for a discussion of the role of international law in pollution control. The analysis concentrates on atmospheric pollution, water pollution and pollution which arises from manufactured goods, especially those produced by multinational corporations. It is concluded that many acute forms of pollution are likely to be tackled at the national level, with international action as a supplement. There are other pollutants which have long-term potential effects of great importance. International legal institutions may be of more significance here; at present, however, agreement on the reality of many of these dangers is not universal. The problem of arranging for the elimination of pollutants from manufactured products is emphasised; in many cases these pollutants only become a hazard after the useful life of the product is ended. Like many other persistent pollutants, however, they frequently have world wide effects which defy unilateral measures taken by individual countries.

Note

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Résumé

L'auteur étudie les principales caractéristiques de la pollution internationale afin d'amorcer la discussion sur le rôle du droit international dans la lutte contre la pollution. L'analyse est centrée sur la pollution atmosphérique, la pollution de l'eau et la pollution provoquée par les produits manufacturés, en particulier ceux produits par des entreprises multinationales. L'auteur conclut que de nombreuses formes aiguës de pollution pourraient être combattues au niveau national, avec le secours complémentaire de mesures internationales. Il y a d'autres polluants qui possèdent d'importants effets potentiels à long terme. Les institutions juridiques internationales peuvent avoir à jouer un plus grand rôle dans ce cas; pour le moment, toutefois, l'accord universel est loin d'être établi quant à réalité de nombre de ces dangers. L'accent est mis principalement sur la nécessité d'accords visant à éliminer les polluants des produits manufacturés; dans nombre de cas, ces polluants ne deviennent dangereux que lorsque la vie utile du produit est achevée. Cependant, à l'exemple de nombreux autres polluants persistants, ils ont souvent des effets universels qui défient les mesures unilatérales prises individuellement par les pays.

Introduction

The contribution which international legal institutions can make towards pollution control and the preservation and enhancement of environmental quality can presumably be examined in at least two ways. Because of the training and outlook of the authors, the other papers in this symposium are likely to begin with the law, and to examine the extent to which its development and use seem appropriate to environmental problems. The present paper is concerned more with the problems themselves; it seeks to provide a broad classification of the major forms of international pollution, and to suggest areas which the international lawyer may find it worthwhile to explore: because the quantitative data are reliable and relevant, because other non-legal means of abatement seem difficult or inadequate, or simply because, in many cases, the recognition of the problem is so recent that there is an opportunity to include the law among the various strategies that can be considered. It should be noted that these criteria do not include the apparent existence of legal means by which the problem might be tackled; the present author is not competent to assess either the extent or the role which international law might play in the problems to be described.

Before embarking on a discussion of the forms of international pollution, it is however necessary to specify and elaborate on a basic assumption contained in the paper. Problems of international pollution are, at best, only indirectly related to economic growth and population growth, and the main attack on pollution problems is not likely to take the form of reduction or elimination of either of these, especially during the remaining decades of the twentieth century. This does not,

of course, imply that there is not a close relationship between growth and pollution: the more growth we have, the greater is the potential pollution. The link has been clearly stated in a recent study to which frequent reference will be made in this paper:

> The genesis of environmental deterioration is to be found in increased population, urbanization, industrialization and technological innovation and their derived products. Normally these are hailed as indicators of growth and standards of the success of public policy. More people with more money enjoying more mobility and more leisure and producing and consuming more per person each year represents both our individual and collective aspirations.
>
> Yet these same goals require ever-increasing quantities of land, water and raw materials. They result in heavier pressures on our environment at all points, causing more air pollution; more crowding in our cities, on our highways and at our beaches; more automobile junkyards; more land stripped for mining; and more species threatened with extinction. The costs and benefits of growth are two sides of the same coin.[1]

It would be difficult to argue with the facts of that statement, but there are great differences of opinion concerning its implications and specifically with whether such costs are inevitable. Many people who work in the physical and biological sciences, and apparently also many of the 'pollution-conscious' members of the general population, seem to draw the conclusion that population growth, the urbanization process, and perhaps even economic growth must somehow or other be stopped if any significant impression is to be made on the problem of environmental pollution

Such views are not shared by many social scientists, nor by the present author.[2] Economic growth undoubtedly has its costs, as has

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1. MacNeill, J.W., Environmental Management, Ottawa, Information Canada, 1971, p. 23.

2. Nor, for that matter, by the author of the passage quoted. Elsewhere he makes it clear that "I believe that the basic goals of economic growth and environmental management are the same, a better quality of life for mankind. I also believe that both are required to achieve it." MacNeill, op. cit., p. vi.

been pointed out by Mishan[3] and others, but damage to the environment comes mainly from economic growth which is essentially uncontrolled. It is also not self-evident that conditions of static or declining populations are ipso facto more favourable to environmental quality improvement than a condition of a rising population. This paper is not an appropriate place to enlarge on this; what matters for the present purpose is that strategies of environmental improvement or pollution control which rest on the elimination of either economic or population growth are largely irrelevant in the foreseeable future. Indeed they may be an unfortunate distraction, wills-o-the-wisp which divert attention, finance and action away from the real problems.

They are irrelevant mainly because, however successful we are in reducing population or economic growth in the long term, over much of the world the pattern has already been set for the next few decades, and the pattern is almost certainly one involving growth, certainly of economic activity, frequently also of population. This is particularly true of North America, because of the low average age of the population. For example, more than half the present population of Canada is below the age of 25. The rate of family formation in future decades will be much greater than anything in the past. From about 330,000 in the period 1960-65, it is expected to rise to 635,000 in the period 1970-75 and to 725,000 by 1975-80.[4] Even if future parents limit their families to two, enough merely to ensure replacement[5] the size of the population must inevitably increase substantially in the short-term,

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3. Mishan, E.J. The Costs of Economic Growth, New York Praeger, 1967, and Growth: The Price we Pay, London, Staples, 1969.

4. Illing, W.M., Population, Family, Household and Labour Force Growth to 1980, Staff Study No. 19, Queen's Printer, Ottawa, 1967, p. 59.

5. To ensure replacement, in fact, more than two children per child-bearing family is required to allow for deaths before reaching child-bearing age and also to allow for replacement of those in the parents' generation who do not have children.

simply because there are not enough deaths at older ages to balance the births. A stable population would ultimately be achieved, but not for several decades, and the campaign to limit family size, even though it were successful, would not do much to diminish environmental problems during the intervening period. Similarly, and a fortiori, for economic conditions: it is anticipated that in Canada more people will enter the labour force between 1965 and 1980 than will enter the labour forces of Great Britain, West Germany and Italy combined.[6] These countries had in 1965 a combined population of 165 million; in Canada it was less than 20 million. The reasons for this great contrast are basically three-fold: the youthful present population, net immigration, and a significant anticipated increase in the female participation rate. Each of these factors, however, originates from people who are alive today: population control cannot help the environmental problems such growth of employment may cause.[7] The only alternative to economic growth in Canada and the U.S.A. during the remainder of this century is a situation in which a substantial proportion of the population will be temporarily or permanently unemployed. Maybe North America should not have allowed itself to get into the position where it is possible to argue that economic growth is needed, if only to provide employment. Maybe we may not be too many decades away from a post-industrial society in which employment is not the means on which the vast majority of the population depends for support. Whatever the merits of these arguments, they are largely irrelevant to the task of reducing

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6. Ibid, p. 78.

7. It could be argued, of course, that if Canada reduced or eliminated immigration, there would be less pressure to create jobs during this period. But since the potential immigrants are already alive, this would merely transfer the problem elsewhere, and in a world context the reconciliation of environmental quality with economic growth is not obviously more difficult in Canada than elsewhere.

pollution and improving environmental quality during the next few decades which, in North America and in much of the world, will have to be accomplished in conditions of rising population and of economic growth.

From a Canadian point of view, this means that such action must take account of the rapid rise in the work force referred to already, during a period when the urban proportion of the population will tend to rise rapidly, where the strongest pressures for growth will be found in what are already the largest cities, in a country where the major concentrations of people and of economic activity form extensions of larger concentrations across the international border.[8] "International" pollution inevitably has a special meaning for Canada:

> An underlying assumption of Canadian environmental strategies is that the United States will meet its obligations for both boundary air and water quality.....If the United States does not meet its obligations, for example in the Great Lakes, Canadian efforts will be to no avail.[9]

The same, of course is true in the reverse direction, but to the extent that pollution is an indirect function of population and economic activity, to that extent Canada is more dependent on the U.S.A. There are in fact two separate, though closely related factors which make Canadian-U.S. cooperation in anti-pollution programmes of greater prima facie concern to Canada. In the main geographical areas where common agreement on policy is needed, the bulk of the problem usually originates in the United States, and, secondly, a much greater proportion of the Canadian population lives in such areas; although total numbers of the American side are larger, they form a smaller proportion of the national population.

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8. See MacNeill, op. cit., esp. Ch. VIII.

9. MacNeill, J.W., "Assumptions Made by the Canadian Government in Establishing Strategies for Environmental Quality Improvement", Paper delivered to the Atlantic Council of the United States Conference on "Goals and Strategies for Environmental Quality Improvement in the Seventies", Washington, D.C., January 1971. p. 30.

There are many dimensions to international pollution which might be considered, but for the sake of simplicity this paper is limited to a general, and indeed superficial, examination of the three major elements: (a) pollution of or through the atmosphere; (b) pollution of or through water bodies, rivers, lakes and oceans; (c) pollution which arises through international transfer of goods, especially through trade. Each of these has a variety of forms which may or may not be amenable to control through legal means; in many cases it is probable that legal solutions are inappropriate, for example because the problems are more effectively solved through other means, or because the relationship between cause and effect may be too indirect for legal remedies at the present time. In other cases it may well be that remedy of an internal pollution problem, by legal or other means, will remedy the external problem also, and specific international legal means are unnecessary. As implied in the preceding discussion, pollution and environmental quality may be regarded as opposite sides of the same coin; subsequent analysis will be as much concerned with improving the latter as curing the former.

Air pollution and its international dimensions

Together with the oceans, the fluid atmosphere is a very efficient distributor of pollution, whether that pollution is in gaseous, liquid or solid form. Most of the problems which seem of major significance at the present time are located in the troposphere; that is, the lowest layers of the atmosphere from the surface to a variable height, say 35,000 ft. or seven miles - roughly the layer below the cruising altitude of present jet airliners. Since air is a compressible fluid held in place by gravity, approximately three quarters of atmospheric mass lies in this thin tropospheric skin around the globe, and within the troposphere are contained most of the components of weather, specifically clouds and water vapour. Within the troposphere also

are contained most of the pollutants, though the fact that air traffic increasingly uses the stratosphere has led to increasing concern about the effect, especially on world climate, of pollutants entering the atmosphere at this level.

Although the troposphere is only a few miles in depth, the physical mixture of air around the globe is very efficient and so is the diffusion of many pollutants. Surface and atmospheric nuclear tests after 1945 have demonstrated this very clearly: radioactive fall-out is quickly detected at a large number of places far away from the explosion. In middle latitudes in particular, the mixing is rapid and effective. In both northern and southern hemispheres the basic circulation of air between latitudes 30^{o} and 60^{o} may be envisaged as a broad current of air flowing round the planet from west to east. Sometimes the current is fairly straight; at other times it develops sinuous waves so that the current may dip down deep into the subtropics and then curve northwards into Arctic before turning southwards again.[10] The Westerlies contain within them the familiar depressions and ridges of the surface weather map; these tend to be carried along in the basic westerly current like moving whirlpools in a stream. Material injected into the atmosphere upwind is likely to fall out of the atmosphere at some point downstream in the system. The length of the time interval between injection and fall out depends on a variety of factors such as the density of the injected material, its tendency to be dissolved or washed out by precipitation, and the vertical stability of the air (i.e. the relative upward and downward motions in the troposphere itself.) Similarly, the distance travelled and the point of fall out depend on all these factors and on the speed and direction of the tropospheric current. The extremes are considerable.

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10. The Westerlies, and the other components of what is usually termed the general circulation of the atmosphere, are described in all basic text books of meteorology.

For instance, during the London smog of 1952, it is believed that there was less than one complete exchange of air between the dense layer of smog (only a few hundred feet deep) and the surrounding air in three days. At the other extreme the Krakatoa volcanic eruption of 1883 threw dust into the atmosphere which remained to give superb sunsets around the world for several years. Between these two extremes there are many opportunities for environmental nuisance. It has been said, for example, that the tall smokestacks of the power stations operated by the British Central Electricity Generating Board have made sulfur one of Britain's most successful invisible exports. Britain probably contributes about one third of the sulfur found in Stockholm's normal winter atmosphere.[11]

In North America, the international implications of such redistribution of pollutants are considerable. The border separating Canada and the U.S.A. lies for all or most of the year in the centre of the basic westerly flow. Although the latter is displaced latitudinally as part of the seasonal shift of the earth's pressure and wind systems, the area between 40° and 50° north lies within the Westerlies virtually the year round. Indeed, the mean position of the principal convergence zone between arctic and tropical air masses, a convergence which is both a necessary feature and the driving force of the Westerlies, coincides very closely with the international boundary, especially in eastern North America. On any individual day, the convergence may lie north or south of the boundary and polluted air may enter Canada

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11. "Putting the S in Sweden", New Scientist, 48, 725, 29 October 1970, p. 209. See also Reiquam, H., "Sulfur: Simulated Long-Range Transport in the Atmosphere", Science, 170, 3955, 16 October 1970, pp. 318-320.

from the United States, or vice versa. In summer, however, the mean position of the convergence lies well to the north of the boundary and, in Bryson's words, "South of Hudson Bay the air on one-third of the days in July is of "United States" origin."[12] This tendency to a northward penetration of air in summer, added to the greater potential sources of polluted air on the U.S. side, makes Canada more vulnerable to U.S. pollution on the broad scale than is true in the reverse direction. The Trail smelter incident, however, emphasises the fact that the traffic of pollutants is a two-way affair.

Demographic and economic projections suggest that potential sources of air pollution in the vicinity of the international boundary are likely to increase rapidly, with Canada again likely to suffer more potential damage from the U.S.A. than it will cause in the reverse direction.

> ".....the projected thirty-year population increment of American cities adjacent to Ontario, Quebec and the Maritimes is three times that projected for Canada as a whole.....it seems evident that the spillovers from this external growth upon Canadian ecological systems can be expected to dwarf pressures generated within our borders."[13]

Although the potential for international air pollution is therefore large, there are some reasonable grounds for the hope that many of the major problems will be dealt with by both the U.S.A. and Canada, without even the need for the development of joint programmes. The basis for this belief is that much of the nuisance of air pollution is likely to be caused in the immediate vicinity of the source. Most particulate pollution tends to fall out very quickly, and the gaseous pollutants, which may survive for a

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12. Bryson, Reid A., "Air Masses, Streamlines, and the Boreal Forest", Geographical Bulletin, 8, 3, 1966, p. 233. This article contains maps showing the position of the principal convergence zones, relative to the international boundary in eastern North America.

13. MacNeill, Environmental Management, loc. cit., p. 65.

long time in the air before reacting chemically, are nevertheless at their most hazardous where they are most concentrated, near to the point of diffusion. Further, the opportunities at the international scale for externalising the diseconomy seem small. Unlike rivers, the wind is likely to transport pollution in all directions. Although it would be possible in principle for a pollution source, e.g. on the shores of the Great Lakes, to avoid penalties imposed in one country by releasing pollutants into the atmosphere only when the wind direction and vertical stability were such that they were carried away from that country, the likelihood that this would be compatible with economic operation of the plant is small. Even where it were feasible (e.g. by neglecting to filter the pollutants out in 'favourable' wind conditions), the Trail smelter case suggests that remedies for such individual international nuisances already exist.

The really acute forms of air pollution, in other words, are likely to be dealt with by the inhabitants of the countries concerned, before they develop to the stage where they become a significant international problem. On the Canadian side, for example, the air pollution legislation of the Province of Ontario requires individual sources of smoke in Toronto and other cities to cease operations when pollution values reach a certain critical value.

If many of the major sources of acute pollution are likely to be eliminated through national or sub-national initiative, there may still be need for some form of international regulation of less acute forms of air pollution. By building high smokestacks it is certainly possible to reduce the concentration of pollutants in the surrounding area but these may, as in the case of British sulfur exports to Sweden, merely transfer the nuisance elewhere at a lower concentration per unit area. The fact that the country

which is the source of the pollution may regard such lower concentrations as acceptable is no reason why another country should be prepared to tolerate such spillovers.

On the other hand, recent evidence seems to suggest that nature may be able to solve many of the problems herself. The problem of pollution involving sulfur, for example, is really only a case of pollution by sulfur dioxide, SO_2 because:

> ".....at a rather low level of concentration, a level not infrequently found in air, inhalation of sulfur dioxide... ...results in temporary spasm of the smooth muscle of the bronchioles; somewhat higher concentrations cause increased mucus production on the walls of the upper airways; still higher concentrations result in severe inflammatory responses in the mucosa, with desquamation of the surface epithelium. These irritant effects of sulfur dioxide, expecially bronchiolar spasm, are aggravated by cold air. The reactions to these effects adversely modify lung function.....[14]

Much of the sulfur present in the atmosphere is not present as sulfur dioxide, and is in fact largely derived from natural sources such as sea spray, decay of organic matter in swamps and volcanic activity. Substantial amounts of SO_2 do enter the world atmosphere, virtually all from artificial sources: a total of 73 million tons of sulfur per year. Of this, 51 million tons are derived from coal combustion, 3 million from petroleum refining, 11 million from petroleum combustion and 8 million from smelting operations. Despite these fairly large totals, the actual amount of SO_2 actually present in the atmosphere does not show a cumulative growth proportional to the input, since there exists a natural 'scavenging cycle' tending to convert the gas into other chemical forms.

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14. Heimann, H., "Effects of Air Pollution on Human Health", pp. 159-220 *in Air Pollution*, World Health Organization, Geneva, 1961, at p. 187.

> Most of the emitted SO_2 becomes SO_4 in the atmosphere as a result of several possible photochemical or physical reactions. This rapid reaction rate plus ready absorption of SO_2 by vegetation contributes to a rapid decrease in concentration outside emission source areas. In the ambient troposphere the majority of the sulfur is present as SO_4.[15]

This 'scavenging cycle', the time required to achieve the conversion, is of the order of about four days for SO_2.

It should certainly not be concluded from this that sulfur dioxide is not really a significant pollution problem; still less can it be concluded that other pollutants do not cause major problems, especially those which are much more persistent in their dangerous forms. What is suggested is that although international regulation and similar remedies may have some role to play in controlling air pollution, the development of such measures should take into account the following facts. (1) In many cases the nuisance controlled by air pollution is at a maximum in the vicinity of the emission. National, or sub-national, action to restrict it may be forthcoming before a need for international action is evident. (2) Many substances in the atmosphere may be derived more from natural sources than from urban or other sources of man-made pollution. Frequently it is not even possible to say that a particular compound is of artificial origin, as it is with SO_2; large amounts may be produced naturally. An excess of the compound (e.g. carbon monoxide) may nevertheless constitute pollution: it is not the presence which is important but the excess. Before international regulations can be framed, therefore, we require not merely monitoring techniques which can measure (or at least

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15. Robinson, E. and R.C. Robbins, "Gaseous Atmosphere Pollutants from Urban and Natural Sources", pp. 50-64 in Singer, S.F., Global Effects of Environmental Pollution, Springer-Verlag, New York 1970, at p. 55. The data on SO_2 emissions earlier in this paragraph are taken from the same source.

estimate) the quantity of the specific compound which represents the pollution, but in many cases we need also agreed standards of both normal background levels of atmospheric concentration and the threshold value at which the pollutant becomes a nuisance. Assuming that the two levels are not the same, there may then be reason to utilise the atmosphere as a waste for the compounds up to the agreed threshold level, and it will not be easy to determine quotients of the right to pollute at the international level, let alone the sub-national one. It is, of course, possible to argue that pollution is pollution and one should eliminate it without regard to threshold level. Such a rigorous doctrine does not seem likely to command the degree of international assent required to make it effective, nor does it seem necessary. For example a domestic oil furnace releases carbon monoxide, a form of pollution, into the atmosphere. In certain conditions of urban smog the threshold may be exceeded and the restrictions are necessary. But is it either feasible or sensible to impose similar restrictions on a solitary rural household?
(3) Because of the existence of natural scavenging cycles, the international, or distant, effects of pollution may be significantly reduced.

The real need, in fact, for international concern on air pollution may be in regard to those forms of pollution which have a cumulative effect: "chronic" rather than "acute" pollution. Several causes of such pollution have been definitely identified, and other sources have been suggested as potential pollutants. Examples include ".....worldwide cloud seeding by automobile exhaust,.....,the effect of jet contrails on cloud cover, or the effect of atmospheric turbidity in reducing the ultraviolet intensity in the Vitamin D band....."[16] It has, for example, been suggested that:

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16. Bryson, R.A. and W.M. Wendland, "Climatic Effects of Atmospheric Pollution", pp. 130-38 in Singer, op. cit., at. 136.

> Taking 3000 as the number of jet aircraft in the air, averaging 500 mi/hr, 50% making contrails, which last an average of 2 hours and spread to a width of $\frac{1}{2}$ mile we have
>
> $$3000 \times 500 \times 0.5 \times 2 \times 0.5 \text{ mi}^2 \text{ of contrails}$$
>
> Dividing by the area of the region in which most of these aircraft are operating we find a 5-10% increase in cirrus in the North American-Atlantic-Europe area.....This is not negligible![17]

It does, however, involve some fairly large assumptions. In many cases we cannot make any guess based on reasonable assumptions, often because we do not know what the normal background level in the atmosphere was before the alleged changes began to take place. Sisler, for example, has examined the possibility that the atmospheric oxygen and nitrogen balances may be threatened by pollution and finds little evidence: "Thus far, a major disruption in the oceans and atmosphere is not apparent."[18] He warns, however, that even if the threat is not acute, it is nevertheless real:

> "It seems obvious that man can shift natural equilibrium forces that make for a healthy balance in nature essential for life, in particular the composition of the atmosphere and the food potential of land and sea."[19]

Jaffe has similarly looked at carbon monoxide levels. CO is produced at large rates at present from both natural and artificial sources.

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17. Ibid, p. 136-37.

18. Sisler, F.D., "Impact of Land and Sea Pollution on the Chemical Stability of the Atmosphere", pp. 12-24 in Singer, S.F., op. cit., at p. 22.

19. Idem

> "Global CO emissions from technological sources and forest fires have recently been estimated to approximate 230 million tons a year.....The aforementioned estimates.....do not include any estimates of CO from other natural sources, whether geophysical or biological in origin."[20]

Approximately 64 million tons of this is estimated to have been emitted from internal combustion engines in the U.S.A. Emissions on this scale should lead to measurable changes in atmospheric concentrations but there is no evidence of this. It seems as though there may be a scavenging process maintaining the present balance, but although several possible mechanisms may be postulated, "The precise removal mechanism, however, is presently unknown."[21]

Although there may therefore be no immediate cause for alarm in respect of these and other chronic pollutants, there are some (e.g. carbon dioxide) where the evidence, although inconclusive, is a little more disturbing,[22] and there may well be other pollutants which are important but are at present unrecognized. From a legal point of view it is unfortunately usually the case that international regulation and control may be most desirable in just those cases where it is most difficult. Added to all the problems we have enunciated this far, chronic pollution usually has the extra characteristic that it is difficult or impossible to link cause and effect. The world levels of CO_2, of condensation trails and of similar pollutants, are composites of emissions by many, perhaps all, nation states.

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20. Jaffe, L.S., "The Global Balance of Carbon Monoxide", pp. 34-49 in Singer, S.F., op. cit., at p. 35.

21. Ibid., p. 46.

22. See, for example, Johnson, F.S., "The Oxygen and Carbon Dioxide Balance in the Earth's Atmosphere", pp. 4-11 in Singer, S.F. op. cit.

All are responsible and all in many cases suffer equally. Individual action to restrain emissions may have little or no effect on the overall world situation and may indeed have a negligible effect on conditions in the country itself. International action may be the only solution, but the technical, institutional and administrative problems facing such action will frequently be formidable. The scientists may not yet be in a position to know definitely whether a danger exists; they may disagree about its severity, or about the critical effects (e.g. are these most serious in regard to humans or to animals?) They may not be sure what atmospheric parameters should be monitored, nor what density of monitoring network in the world is required. There is likely to be disagreement as to who should pay for that network and there will be still greater debate over the interpretation of the results and the implications for international action.

To some extent the treaty banning nuclear explosions which release radioactive particles into the atmosphere gives hope that these difficulties can be resolved. Yet a superficial examination of that experience emphasises the problems. The treaty has not eliminated atmospheric nuclear testing: several nations in the 'nuclear club' have not signed the treaty and indeed they can now undertake such tests in the knowledge that, local effects apart, their own populations are not likely to suffer from such tests, since the critical threshold is unlikely to be crossed. This attitude can be regarded as selfish, but it is likely to be repeated in other fields. One rationalisation for that attitude is also likely to be repeated, that many of the countries seeking to limit or eliminate a particular form of pollution have derived benefit from creating such pollution in the past and now wish to deprive other countries of the same benefits. An undercurrent expressing this

feeling is already recognizable in attitudes towards the UN Conference on The Human Environment in 1972. Further, the test-ban treaty is probably atypical in that the origins of the pollution, though multinational, are highly specific; most other forms of atmospheric pollution come either from a variety of activities which inject the pollution into the atmosphere or from a large number of individual sources of that activity. If condensation trails do represent a problem, for example, we are faced with the need to regulate every flight which reaches the level at which such trails are formed. Even this is prima facie easier than controlling the millions of sources of emission which may be responsible for releasing a particular product of combustion.

The suggestions made earlier, that maximum use should be made of national action, of natural scavenging cycles and of other means of preserving world environmental quality without international institutions, are therefore offered as much to keep the problem at the international scale manageable as for any other reason. The potential size of the problem of chronic or cumulative pollution is extremely large; it is noteworthy, for example, that the first subject referred by the British Government to its recently appointed standing Royal Commission on Environmental Quality was that of the adequacy of current research into the possible long-term effects of atmospheric pollution on weather and climate. However, in investigating the subject, the Royal Commission found little evidence that significant changes are taking place: "We see no cause for alarm or for "crash" programmes of research", although extension of international monitoring and research preferably under the auspices of the World Meteorological Organization, is recommended.[23] If this conclusion is justified, there is cause for

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23. U.K., Royal Commission on Environmental Pollution, First Report, London H.M.S.O., Cmnd. 4585, 1971, para 128. See Also Chapter V.

relief, since there seems a long way to go before we have developed adequate international means to manage those atmospheric pollutants which require such action. It seems likely that a major step forward may be taken at the U.N. Conference in Stockholm next year. One of its lasting results may be the establishment of adequate monitoring and surveillance systems for pollution on a global scale.

Water Pollution

Like the gaseous atmosphere, water is a fluid which both directly supports life and is a medium in which gases, liquids and solids can be transported. To a far greater extent than the atmosphere, and probably to a greater extent than the land areas, it also represents a quasi-permanent sink: the entity to which pollutants are ultimately transported and in which they may remain for long periods. Together, oceans and atmosphere form a single inter-connected system; within this system the major sub-system of the hydrological cycle is a complex series of interrelationships which ensures a wide dispersion of many pollutants, provided that the pollutant survives in the undesirable form while the transport is being accomplished. To consider air pollution as a distinct facet of pollution, as was done in the preceding section, is to isolate, and over-simplify, what is in fact part of a much more complex whole. As a further simplification, and again over-simplification, in this section the pollution of rivers, lakes and the sea will be examined separately.

As a preliminary, however, it is helpful to make another type of simplification: that between three types of water pollutant: degradable, non-degradable and persistent. Degradable pollutants, as their name implies, are capable of being broken down in the water body by bacteria and other organisms, a process which provides nitrogen, phosphorus and carbon, and requires oxygen.

> Degradable pollutants include not only human, animal and plant wastes but also a wide range of household cleaning agents, agricultural fertilizers, industrial chemicals and refuse. The most widespread primary source of degradable waste is domestic sewage but, in terms of volume, industry and agriculture produce significantly greater amounts. Most of the industrial component is generated by the food processing, pulp and paper and chemical industries. A single chemical or pulp and paper mill, for example, can produce an organic waste load equivalent to the sewage discharge from a large city.[24]

Non-degradable pollutants by contrast, undergo little or no change: they are almost wholly inorganic, and include dust, sand or soil eroded from the land surface, mineral salts, including salt used in urban snow removal; they include also metallic salts and acids from surface and sub-surface mines. Thirdly,:

> The persistent pollutants include substances which do not fit easily into either of the above categories. They are called persistent because their complex chemical structure resists attack by aquatic organisms or by chemical treatment processes. Organic materials of this class degrade very slowly and may remain in an aquifer, lake or bay for very long periods. Or they may travel great distances, carried by rivers and by lake and ocean currents and by aquatic life. The same is true of inorganic materials, except that they don't degrade at all.[25]

This group includes most pesticides and herbicides, such as DDT, together with:

> .....petroleum and the many products resulting from the distillation of petroleum, such as phenols. And it includes long-lived radioactive products..... The most fertile primary source of persistent pollutants are the petro-chemical, agro-chemical and atomic industries. The petroleum industry, with its off-shore drilling and tanker transportation activities, also ranks very high.[26]

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24. MacNeill, Environmental Management, loc. cit., p. 158

25. Idem

26. Ibid., p. 159.

To these forms of pollution which involve the addition to the water of specific substances should be added thermal pollution, i.e. damage which is caused by a change in the water temperature, and also that damage which is caused by man's physical interference with natural water circulation.

Historically, the main problems associated with river pollution have been those caused by degradable organic sewage. Water borne diseases like typhoid, cholera and dysentry, all frequently caused by contamination of drinking supplies by sewage, were the main factors leading to the development of systems for the supply of safe water in advanced industrial countries during the last hundred years or more. The extension of such systems to the whole world provides the World Health Organization with one of its biggest tasks at present.[27] The problems caused by degradable pollutants are still of great importance, as the present cholera pandemic, affecting much of the Eastern Hemisphere, has demonstrated. Increasingly, however, the management of organic wastes is well understood and a matter of routine. To convey this a little more vividly, in Britain the inhabitants of London (and of course visitors to that city) take water from their faucets which somewhat earlier was discharged as sewage into the Thames by the city of Reading; still earlier the same water formed the supplies and sewage of the city of Oxford on the same river. There have been several serious suggestions, both in Europe and North America, that such recycling need not be so widely separated in space.[28] If one city can drink another's sewage, there seems little reason (and some justification!) why it should not drink its own.

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27. See, for example, Dieterich, B.H. and J.H. Henderson, Urban Water Supply Conditions and Needs in Seventy-Five Developing Countries, Public Health Papers No. 23, World Health Organization, Geneva, 1963.

28. See, for example, Cecil, L.K., "Municipal Wastewater as a Water Resource" pp. 95-112 in Western Resources Conference 1970, Urban Demands on Natural Resources, University of Denver 1970.

The problems generated by the injection into rivers and streams of degradable pollutants are therefore frequently ones which involve competition by other uses of that water. Until the organic material is decomposed, for example, the sewage makes the river unpleasant or unsafe for recreational use. Such problems are not insignificant, but they do not usually have international implications except where a boundary water is used for dumping of sewage by one country while its neighbour wishes to use this water for other purposes. A pulp mill, for example, may pollute heavily a river which forms the international border or which crosses the border still in a polluted condition. Such situations exist at present on the Canada-U.S.A. border and require solutions. But, like the Trail smelter, such cases are likely to be comparatively rare: the fact that the nuisance has an international aspect is almost incidental. Although in the short term such nuisances may be eliminated only if international pressure is applied, in the long run it seems reasonable to expect that both Canada and the U.S.A. will be as concerned to reduce or eliminate pollution by wholly domestic plants as they will be to eliminate a source of international pollution.

The situation is different, and more intractable, in the case of non-degradable or persistent pollutants. Here the classic area at the international level is Europe and in particular the Rhine and the Danube. To a very considerable extent, much of the work in regard to European water quality improvement undertaken by bodies such as the UN Economic Commission for Europe, the Organization for Economic Cooperation and Development, and the Council of Europe, is directed to finding means by which the quality of these major international rivers may be improved.

The government of the Netherlands reported on the problems caused by pollution of the Rhine to the International Conference on Water for Peace in 1967. It pointed out that "The river Rhine contributes about 65% of the supply of the Netherlands with fresh water",[29] and that the average annual volume of Rhine water entering the country is "more than six times as much as the theoretical amount of water, that might be retained in our country by storage of all "useful precipitation"",[30] i.e. after subtracting the amount returned to the atmosphere by evaporation and transpiration. Yet the water was polluted with high concentrations of common salt (NaCl) and calcium chloride ($CaCl_2$), derived mainly from three sources: potassium mines in Alsace, coal mines in the Ruhr, and the soda industry. Sulphates were also a major pollutant and oily substances were estimated at about 80 to 90 thousand tons a year, of which about 10,000 tons were probably derived from inland navigation.

Despite - or because of - the magnitude of such problems, the development of adequate institutions to solve them is a slow process. The Economic Commission for Europe summarised the present position in a survey published in 1970:

> "The need for international cooperation in water resource development has long been felt in Europe; agreements and institutions set up for this purpose here existed for many years, particularly as regards inland waterways navigation on large rivers such as the Danube and the Rhine. But more recently there has come about a new sense of urgency and a dissatisfaction with the rather sporadic and casual cooperation across frontiers which now prevails in Europe particularly as regards the use and conservation of such shared waters for purposes other than navigation."[31]

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29. State of Water Pollution in the Netherlands: International Conference on Water for Peace, Washington, D.C., May 1967, document p/586, p. 1.

30. Idem.

31. United Nations, Economic Commission for Europe, Trends in Water Resources Use and Development in the ECE Region, ST/ECE/WATER/1, United Nations, New York, 1970, Annex IV, p. 7.

Significantly for the present discussion, the ECE senses "a growing recognition" that

> ..."because international problems of water resource development cannot be solved on the basis of an appeal to a body of recognized international law setting out the rights and duties of states, these problems must be dealt with by seeking practical equitable solutions based on the principle that internationally shared waters are a joint resource which should be developed in the common interest of all concerned.....[32]

As the ECE admits, "there seems to be a general recognition in Europe that much remains to be done to place such co-operation on a more systematic basis",[33] though the creation of the ECE Committee on Water Problems is itself a sign of progress.

A major consideration in examining the role which the rule of law can play in solving pollution problems of this type is that the preservation or restoration of water quality must normally be achieved while ensuring the continued use of the river for a variety of purposes. Some of these uses are compatible with or dependent on the maintenance of high water quality, e.g. most forms of recreational use. In many cases, however, there are strong conflicts between quality and use. In the examples of the Rhine and Danube, the very great use which is made of the rivers as a medium for transport is obviously in potential and actual conflict with the maintenance of water quality.

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32. Idem.

33. Ibid., Annex IV, p. 21.

Despite the magnitude and multiplicity of such conflicts, the development of international legal agreements seems both a feasible and an essential contribution to the solution of the problems of rivers such as the Rhine or Danube, provided of course, the nations concerned desire agreement. The nature and sources of most pollutants are fairly well understood and, although monitoring techniques still require improvement, the technical problems are neither difficult to define nor incapable of solution. It remains to be seen whether the institutional difficulties can be overcome.

If the Rhine and Danube provide loci classici of pollution of international rivers, the Great Lakes must be the outstanding examples of water quality problems found in international lakes. The Lakes demonstrate in particular the problems arising from multiple demands on the water resources, and the slow turnover time which hinders restoration of quality. They also demonstrate, more convincingly than most international rivers, the mutual need for cooperation among the nations which divide the waters of international lakes. In the case of river pollution, the main international problem arises because of an ability to externalise a nuisance by transferring it elsewhere: an industrial or other source of pollution in a particular country solves its waste disposal problem at minimum cost by sending the waste downstream into a jurisdiction which has little or no power to control the polluter. This, essentially, was also the situation which required an international solution in the atmospheric case of the Trail smelter. In the Great Lakes, and in other similar situations, however, the position is different. As the present writer has noted elsewhere, although the international border runs through four of the lakes,

> .....a definition of what is "Canadian" and "United States" water is a nonsense definition. All that can be said is that at a particular point in time a particular unit volume of water is in a particular position with respect to the border, but this is true of that point of time only.....[34]

Hence, if pollution is deposited in the lakes, the same thing happens to it as to the bread cast upon the waters in the Book of Ecclesiastes: as a recent report on pollution in Lake Erie and Ontario put it:

> .....there is substantial mixing of waters in the lakes to the extent that concentration levels of polluting materials are remarkably uniform throughout extensive areas of each lake. Thus, there appears to be no doubt that all major sources of pollution to the lakes have contributed directly, or indirectly, to their generally degraded condition.[35]

Not merely is the polluter also the polluted, it is also obvious that unilateral or uncoordinated action will be of little benefit where, as in the Great Lakes, both the countries concerned are the sources of pollution. What is necessary is not simply action, but concerted action to implement a common policy. The time required for such action to show results is usually much longer than in the case of rivers, where the speed of the water is such that changes in pollution patterns may lead to quasi-instantaneous improvements. In the case of lake water, where it is necessary to replace the polluted water and then to maintain the higher quality such measures must take into account the substantial amount of time required to exchange the waters contained in units as large as the Great Lakes. It is perhaps fortunate that the greatest quantities of pollution have been poured into Lake Erie: the shallowness of this lake has been a factor in its rapid deterioration and this in turn has helped to attract public attention to

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34. Jackson, C.I., The Spatial Dimensions of Environmental Management in Canada, Geographical Paper No. 46, Ottawa, Information Canada, 1971, p. 4.

35. International Lake Erie Water Pollution Board et al., Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River, 1969, Vol. I, p. 7.

the general problem of pollution. Because the lake is so shallow, however, the flushing time is only a matter of about six years and remedial measures can have a significant effect in that order of time.[36] In the other Great Lakes, the situation is very different. The water quality of these lakes is generally better than in Lake Erie, but this is to some extent misleading. The deeper and larger lakes can absorb greater quantities of pollutants for a given amount of overall quality reduction than can Lake Erie, but this probably does not make the task of restoring that quality in the deeper lakes any easier because of the large volumes that require treatment of flushing. To add to the problems we have identified already, therefore, must be added the difficulty of evaluating the costs and benefits of using bodies as large as the Great Lakes as refuse dumps or sewers; the amount of time required for restoration, especially if it depends on flushing, is far beyond any normal time period used in such assessments. The time required to flush the basin containing Lake Michigan is approximately one hundred years. That lake receives a considerable amount of pollution at the present time. Unlike the other Great Lakes, it lies entirely within the United States. Since its natural outlet is into Lake Huron, however, the deterioration of its quality remains a matter for international concern.

The types of pollution found in the Great Lakes include most or all of those found in major river systems.[37] In addition, however, lakes are particularly subject to problems due to eutrophication and to environmental damage caused by the creation of artificial channels for navigation.

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36. It should be remembered, however, that removal of polluted water is only a partial solution; mercury and other pollutants may remain as bottom deposits.

37. See the map to be published in April 1971 by the Government of Canada. Entitled Great Lakes Water Use it summarises the present situation in all the lakes and in their drainage basins on both sides of the international boundary.

Eutrophication is a process of water quality deterioration which can ultimately lead to the disappearance of all life in a lake. Paradoxically, this is achieved by a vast increase in the total quantity of organic life during the early stages. The key to the process is the algae: the main plant life of the lakes. These depend for their growth on nutrients such as phosphorus, nitrogen, carbon, calcium and iron:

> The problem is that increasing volumes of man-made nutrients are ending up in our water bodies where they accelerate the growth of prodigious quantities of algae. Some varieties of algae do not enter the food chain [i.e. they are not consumed by fish] and their growth is not controlled by it. As they decompose, they consume large quantities of oxygen which is then not available to fish and aquatic life. The fish and other life gradually disappear. The lake takes on a new look as algae bloom and dead fish are washed up on beaches. It also takes on a new taste and other chemicals have to be added to make even potable water palatable for human use. Gradually a lake becomes devoid of life and a hazard to health.[38]

Although the basic process is simple, the quantitative relationship between eutrophication and incoming nutrients is more complex and is by no means fully understood. Eutrophication is again a process which is reaching a critical stage in Lake Erie, but in MacNeill's words "hardly a lake in the settled regions of the world is not suffering":[39] although Lake Erie, especially the western basin, is in a serious state, similar problems affect Lake Ontario and other lakes, both national and international.

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38. MacNeill, Environmental Management, loc. cit., p. 162.

39. Ibid., pp. 162-163.

Eutrophication can be accelerated by thermal pollution. In this context it has been estimated that:

> .....there will be a thirteenfold increase in waste heat discharge into Lakes Erie and Ontario over the next 30 years. By the year 2000 the waste heat input into Lake Ontario in January could be equivalent to eight percent of the solar energy reaching the lake in that month.[40]

However it has not been clearly demonstrated that the present discharge of heat into the Great Lakes is having a deleterious effect. The water in the Great Lakes is fairly cold and such heat may have desirable biological and other effects.

More obviously damaging has been an unexpected consequence of the improvement of navigation in the Great Lakes system which has enabled the sea lamprey to invade the upper lakes. This is a parasite which attaches itself in particular to the lake trout. Throughout the Great Lakes, recent decades have seen a decline of the catch of more valuable species such as whitefish and lake trout, and conversely a rise in the catch of less valuable (and more pollution-tolerant) species such as alewife and carp.

Translating the preceding paragraphs into a more optimistic view, the Great Lakes represent one of the largest needs and one of the greatest opportunities for international environmental action in the world today. In view of the wealth of the U.S.A. and Canada, the large number of scientists and others already working on the technical problems, and the bilateral rather than multilateral character of the institutional problems at the international level, it seems reasonable to suggest that if the pollution of the Great Lakes cannot be tackled quickly and effectively, there is little basis for hope elsewhere in the world. That there is reasonable cause for optimism is suggested by the activities of the International Joint Commission.

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40. Ibid., p. 163.

It has recently produced an agreed statement of the main problems in Lakes Erie and Ontario and an estimate of what, technically, financially and institutionally is required to solve the problems. It has also suggested that a similar investigation should be made of the upper Great Lakes, including Lake Michigan. From a Canadian viewpoint the Great Lakes are probably the largest and are certainly one of the most acute environmental problems facing the country, at least so far as the deterioration of the physical environment is concerned.

In turning to those pollution problems which are characteristic of the sea, the present author is aware that not merely are two other papers at this conference directly concerned with such matters, but one of those who will discuss the paper is himself the author of a major memoir on marine ecology. The following comments are therefore intended only as a background to their contributions.

It is convenient to consider the subject of marine pollution from two standpoints: the pollution of the marine environment, including the shoreline, by ships, oil-rigs and similar oceanic sources, and secondly marine pollution which is derived from terrestrial sources, either directly or via surface run-off.

Although the subject will presumably be discussed in more detail in other papers mention may be made of the view recently expressed by Neumann that problems of oil pollution "have emphasized the magnitude of the division between maritime and coastal states."[41] The Canadian view naturally tends to be that of a coastal state: Canada, after all, has

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41. Neuman, R.M., "Oil on Troubled Waters: The International Control of Marine Pollution", Journal of Maritime Law and Commerce, 2, 2, 1971, pp. 349-361 at p. 349.

almost the longest coastline of any country in the world. Neuman has quoted the Canadian view expressed at the Law of the Sea Conference in Lima in 1970:

> The major maritime powers have insisted for too long on a peculiar conception of the freedom of the seas in which freedom has tended to mean license, in which equality has tended to be translated into hegemony, in which everybody's business has tended to become nobody's business and consequently has been left uncared for...."[42]

Neuman is however critical of the Canadian assertion of jurisdiction in the Arctic contained in the Arctic Water Pollution Prevention Act 1970. He claims that "The problem of maritime oil pollution defies solutions based on the assertion or allocation of national jurisdictions",[43] and he also considers the Canadian belief that arctic oil pollution represents a threat to its national security is one which is difficult to sustain.[44] He is entitled to his opinion, but if the Act which asserts that jurisdiction is considered in the context of other Canadian legislation enacted during the same session, the importance which the Canadian government attaches to the maintenance of environmental quality is evident. The Canada Water Act, for example, is a major piece of legislation designed to improve water quality in cooperation with the provinces. The Northern Inland Waters Act provides similar protection for the rivers of the Yukon and Northwest Territories. Amendments to the Canada Shipping Act have provided increased protection against pollution on the Atlantic and Pacific coasts of Canada. More recently there have been significant amendments to the Fisheries Act and Land Use Regulations have been developed for the N.W.T. and Yukon which enable strict environmental protection of the arctic land areas. In this context it does not seem justifiable to dismiss the argument of national security so lightly.

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42. Quoted by Neuman, op. cit., footnote 5.

43. Ibid., p. 351.

44. Ibid., pp. 357-9.

This legislation does in fact reflect a situation foreshadowed by McDougal and Burke in 1962:

> In the calculable future, states will hardly regard their security interests, that is, their interests in protecting all their values from attack and possible destruction, as of any less vital importance to them than their particular economic and other interests.[45]

Turning to the other aspect of marine pollution, Singer has recently remarked that "The oceans have been termed the 'ultimate sink' for the natural wastes of the world".[46] From the collection of papers to which this remark is prefaced, however, it seems that there still exists considerable doubt about the effect of these wastes on the oceans. In part this is because our scientific knowledge of the oceans is still extremely fragmentary, although the pace of research is increasing.

For example, Goldberg argues that "Between 4000 and 5000 tons of mercury per year most probably enter the oceans as a result of the release of man utilized compounds to the rivers and to the atmosphere."[47] This mercury, he suggests, is likely to be concentrated by fish in a manner similar to that which has occurred in fresh water environments. However at the time his paper was written "this input has not been sought or identified in the marine environment".[48] More recently, evidence of such concentrations

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45. McDougal, M.S. and W.T. Burke, The Public Order of the Oceans, A Contemporary International Law of the Sea, Yale University Press, 1962, pp. 79-80

46. Singer, S.F., op. cit., p. 177.

47. Goldberg, E.D., "The Chemical Invasion of the Oceans by Man", pp. 178-185 in Singer, S.F., op. cit. at p. 178.

48. Idem.

has been discovered, and they are especially significant in mediterranean seas. "Indeed, in some areas around Scandinavia, they have reached the point at which fisheries have had to be closed down."[49] Similar scientific caution is contained in Ketchum's opinion that "So far the pollution of the high seas has been identified but no direct effect on the total production of living material has been demonstrated there."[50] The problem, if it does exist, is one which is of considerable potential importance for the sea as a source of food. Although "the sea offers little promise in meeting the food requirements of our expanding [world] populations",[51] the sea is a rich source of protein "and it is even now supplying half of the annual intake of animal protein for nearly half of the world's population."[52]

On the high seas, in summary, the problems at present are difficult to define, but are probably not yet critical. The situation is significantly different, however, in estuaries and in enclosed seas. Lundholm, for instance, has shown that since 1900 the oxygen content of the deep water in the Baltic has declined at an increasing rate from about 2.7 ml/l to almost zero; during the past thirty years the phosphorus content has tripled.[53] Such anaerobic

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49. U.K. Royal Commission on Environmental Pollution, op. cit., para. 60.

50. Ketchum, B.H., "Biological Aspects of Global Marine Pollution", pp. 190-194 in Singer, S.F., op. cit. at p. 194.

51. Ibid., p. 192.

52. Idem.

53. Lundholm, B., "Interactions between Oceans and Terrestrial Ecosystems", pp. 195-201 in Singer, S.F., op. cit., Fig. 1.

conditions prevent higher organic life. Lundholm tentatively suggests that "The reasons for these changes are not known but is it (sic) possible that pollution and especially eutrophication is one of the reasons."[54] Other commentators would probably have been less cautious.

It was noted earlier that the Royal Commission on Environmental Pollution in the United Kingdom did not think that a critical problem existed in regard to long-term climatic changes. On other pollution problems considered in its first report it is equally reassuring: The Times described the Commission members as "cautious observers of possible dooms".[55] On the question of marine pollution, however, the Commission was more urgent in tone:

> In shallow waters, like the North Sea, urgent decsions may have to be made about the dumping of noxious wastes. The problems of sea pollution are being studied by scientists in several countries. But we think there is a need, without waiting for the results of these studies, for a comprehensive enquiry into the extent of discharges and dumping of wastes into tidal waters, estuaries and the seas round our coasts, and into the kinds of control which should be exercised.[56]

This enquiry is at present in progress by the Royal Commission; on the question of controls it has already indicated its belief that:

> The problem is too complex to be resolved by "blanket" international controls which do not take account of local conditions, and it is likely that localised international agreements would be much more effective.[57]

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54. Ibid., p. 196.

55. The Times, February 24, 1971.

56. U.K. Royal Commission on Environmental Pollution, op. cit., para. 86.

57. Ibid., para. 66.

In a North American context, similar problems and the difficulties likely to be encountered in their solution, have been described by Black:

> .....monitoring technology suitable for measuring organic and chemical wastes in the estuaries and the shallow waters of the Shelf has not been developed with an appreciation of the characteristics to be measured. Base line data and estuarine models to further estuarine research are lacking; there is no mass transport research on the dispersion, transport, and chemical actions of waste in salt water or their effect on environmental and biotic quality from estuary to estuary, along the coast or out to sea. Because of the great variation in estuarine waters, it is extremely difficult to develop pollution criteria for such waters because the waste content of the estuary is neither qualitatively nor quantitatively known..... There are no studies to measure ice-cover pollution relationships; or the relationship between these and the marine biota systems. Although estuarines (sic) are rich biological areas and are the greatest marine producing areas of the ocean and most readily accessible to man, nevertheless estuaries remain the least understood parts of the ocean. Because of the expanding population and industrial activity, these are the areas where water contamination is greatest and will continue to grow worse in future."[58]

Black was writing about the Gulf of St. Lawrence; much of what he describes, however, is true of the international setting of the Straits of Georgia and Juan de Fuca. Black drew particular attention to the effect of pollution in the Gulf of St. Lawrence on shellfish:

> .....the degradation of water through domestic sewage has resulted in the closure of shellfish beds in the Maritimes. The number of areas closed to fishermen has grown from about 48 in 1940 to about 183 in 1970..... The closures affect 25 to 50 miles of Prince Edward Island's coastline and about 100 to 200 miles of Nova Scotia's coastline. Ruggles notes that some 25 percent of the oyster beds are closed because of contamination by sewage and effluents and over one-fifth of the useable clam beds are closed.[59]

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58. Black, W.A., A View from Water Street, Canada Department of Energy, Mines and Resources, Internal Paper, 1970.

59. Idem.

In this context, it has been found by Paish, while investigating the potential for an underwater park in the Straits of Georgia, that the oyster is a reliable indicator of waters which have high recreation potential.[60]

Pollution by International Transfer of Goods

So far, this paper has covered the familiar ground of water and air pollution, which are generally recognized as the principal agents of pollution crossing or extending beyond national borders. In the recent study of Global Effects of Environmental Pollution edited by S. Fred Singer, to which frequent reference has been made, four broad themes are explored in a series of papers: "Chemical Balance of Gases in the Earth's Atmosphere", "Nitrogen Compounds in Soil, Water, Atmosphere and Precipitation"; "Effects of Atmospheric Pollution on Climate" and "Worldwide Ocean Pollution by Toxic Wastes."

In the preceding analysis an attempt was made to illustrate the importance of these forms of international pollution, though the variety of such pollution and its implications have scarcely been outlined. There is, however, another major type of international pollution, to which much less explicit attention has been paid in the past. This arises from the international transfer of pollutants in the form of goods.

Strictly speaking, perhaps, this is not a distinct type of pollution but merely a convenient means of analysing sources of pollution which may not become an environmental hazard until they enter the water or air. The reason why this type of pollution merits separate analysis is that to some extent it has characteristics which are the reverse of those already described

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60. Personal communication.

and which may therefore imply a different strategy of international control. Up to the present this paper has been mainly concerned with demonstrating the need to regulate sources of pollution which originate in a single country but which then become transported by wind or water so as to become a nuisance or danger far beyond that country. The type of international pollution discussed in this section may eventually have similar effects, but of equal significance is the fact that the pollutant is not generated in the country, but enters it in the flow of goods across international borders.

> The post-war growth in the number and varieties of new products is often cited as one of the marvels of technology. And it is. Yet each one of these new products is, or eventually becomes, a pollutant - audio, visual, solid, liquid or gaseous.....
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> ..... Nearly 500,000 organic chemicals have been produced since World War II, most of them synthetically. Hundreds of them are present in treated water supplies at low concentrations but we do not know what chemicals are present or in what concentrations. Chronic toxicity tests are very expensive, as high as $50,000 to $250,000 per compound and there is an acute shortage of specialists in toxicology.[61]

Much of the research and development which gives rise to such products is of course national in character, but to an increasing extent it is also sponsored by multinational corporations or undertaken with an international market as the ultimate objective. Indeed, it is not essential that the product (the potential pollutant) should cross national boundaries; frequently it is the expertise and the patents which move and the products are manufactured in a variety of countries by the same mutlinational corporation or by licensees. The value of the products of multinational corporations exceed the total value of all world trade.[62] It has also been suggested

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61. MacNeill, Environmental Management, loc. cit., p. 46. See also Herfindahl, O.C. and A.V. Kneese, Quality of the Environment, Baltimore, Johns Hopkins University Press, 1965, p. 17.

62. MacNeill, Environmental Management, loc. cit., p. 49.

that by the end of the century "the world economy will be more than half internationalized".[63]

Nor merely are multinational corporations the source of much of what constitutes the "raw material" of pollution, they are of equal significance as agents in the drive against pollution, because of their worldwide influence and because of the same resources of research and development which they can marshal towards environmental improvement. In Canada, for example, 83 percent of all research and development expenditures are incurred by seven industrial sectors, all of them pollution-intensive at present and all with a significant proportion of their activity controlled by multinational corporations.[64] These are construction machinery, transportation equipment, electrical products, chemicals, petroleum, paper and primary metals.

> Yet as [the Royal Commission on Farm Machinery] recently noted, "To an important degree, these multi-national corporations are independent of the national authority of individual countries. At the present time, no international authority exists which can exercise authority over them." This has far-reaching implications when one considers the probable future needs to subject these corporations to environmental management strategies, either regulatory strategies or strategies designed to induce them to anticipate environmental costs and take them into account in their production and marketing decisions.[65]

Whether international legal institutions have a role to play in this regard is for others to say, but there seem to be few fields where the benefit of effective institutions are more obvious. To large extent controls can and should be applied by each country, but this is unlikely to be adequate to solve the problem:

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63. Quoted by MacNeill, Idem., from Polk, J., "The Rise of World Corporations", Saturday Review, 52, November 22, 1969, pp. 32-33.

64. MacNeill, Environmental Management, loc. cit., p. 48.

65. Ibid., p. 50.

> Smaller countries like Canada or even some of the major nations may not be able to enforce certain types of environmental strategies on their own. This may be because the country lacks market leverage, or because the innovation is developed in one country and applied in another that is unaware of its harmful effects. It may be because of international competition.[66]

One example of the type of problem which arises from the spread of goods through multinational corporations is worth examining in a little more detail. It will emerge later that there are no obvious corporate or human villains in this instance, which may not be true of other problems. The following summary relies heavily on a recent paper by Gustafson,[67] and concerns the role of substances called polychlorinated biphenyls or PCBs.

PCBs are synthetic chemicals which have been produced commercially for about forty years. Within the last decade or so, however, their use has grown rapidly and still more recently the environmental problems they generate have become recognized, if not widely known.

One of the most important characteristics of PCBs is the fact that they have a wide variety of uses, unlike DDT, for example, which is an insecticide and nothing else. Probably the use requiring the largest quantities of PCBs is that of a coolant and insulator in high-voltage transformers. Were this in fact the sole use, the pollution hazard would be well-defined and easy to control. However,

> Other uses of PCB's include formulation into ballasts for fluorescent fixtures; impregnation of cotton and asbestos for braided insulation of electrical wiring; a plasticizer in wire and cable coatings;.....Miscellaneous uses include: formulation into some epoxy paints; protective coatings for wood, metal and concrete; adhesives; and in carbonless reproducing paper.[68]

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66. Idem.

67. Gustafson, C.G., "PCB's - prevalent and persistent", Environmental Science and Technology, 4, 10, 1970, pp. 814-819.

68. Ibid., p. 817.

Because of their value in the manufacture of these and other products, PCBs are everywhere. The reader of this paper may be sitting on them, since they are often used as plasticizers for credit cards; in other words they occur in a wide variety of manufactured goods, although as PCBs they are not obvious components of such goods.

As a pollutant of the environment, PCBs have much in common with DDT, especially in regard to distribution and effects. Wherever one looks for PCBs they appear to be present:

> Rainwater in England, brown seals off the coast of Scotland, white-tailed eagles in Sweden, cod in the Baltic Sea, mussels in The Netherlands,..... shrimp in Florida, river water in Japan, waters in the Great Lakes, human hair, and human adipose tissue - samples of all these have been found to contain PCBs.....[69]

The environmental problems which they cause are most obvious in regard to wildlife and especially the predators which concentrate PCBs ingested by the prey they eat. The chronic toxicity of PCBs manifests itself in the laying of thin-shelled birds' eggs which have a very low probability of survival. Perhaps even more important, PCBs appear to affect the date at which egg laying takes place, again reducing the probability of success. PCBs have been blamed for the threat to the brown pelican, for example:

> On the Anacapa Islands off the California coast, no young were hatched last year [1969] from 300 pairs of nesting birds. The shells of most eggs laid were so thin that a dent occurred when the egg was picked up.[70]

The similarity to DDT in effect is apparent, but there are wide differences between PCBs and DDT in regard to distribution of the pollutants and their control. DDT is in the environment because it was deliberately put there

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69. Idem.

70. Ibid., p. 815.

as an insecticide; PCBs have entered the environment almost as an accident, usually because the product they are part of has been disposed of as waste.

> Products containing PCB's.....find their way to the city dump or incinerator for burning. The PCB's do not burn, but are vaporized. They are then carried into the atmosphere.....and are subsequently returned to the surface of the earth, into the rivers, lakes and oceans..... Another source is probably land run-off from industrial wastes and dumps. A third source is the point of manufacture and the plants where PCB's are processed into other products.[71]

In one respect therefore, DDT is a fairly easy nuisance with which to deal. The compound is an insecticide with no alternative uses. Once the decision is taken that its use should be prohibited or strictly controlled, the execution of that decision is straightforward. With PCBs, and presumably with many other similar compounds, however, the multiplicity of uses, especially in manufactured goods, is such that an alternative strategy must be developed.

It was remarked earlier that there appear to be no villains in the PCB story. Whether this is true or not remains to be seen, but certainly some credit is due at present to the Monsanto Corporation. It so happens that the only manufacturer of PCBs in the United States is Monsanto, which markets them under the name of Aroclor. In a postscript to his paper, Gustafson remarked that

> The Monsanto Co. stated recently.....that as of August 30 [1970], it would no longer sell PCB's to customers for use in general plasticizer operations where disposal of the end-products cannot be controlled. After some lag period..... the quantity of PCB's getting into the atmosphere may be substantially reduced. If Monsanto's former customers look for PCB substitutes, rather than purchasing PCB's from manufacturers in Japan and Europe, the projected decrease could become a reality.[72]

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71. Ibid., p. 818.

72. Ibid., p. 814.

Monsanto is a multinational corporation, and its action demonstrates the opportunity for international pollution control which such companies offer, whether that control is applied internationally or enforced externally. In this instance one might wish that the company had a world monopoly of PCB manufacture. It should be noted, however, that since it cannot control the world market, the control device is highly imperfect, even as a means of reducing the environmental nuisance in the countries to which the ban applies. Both DDT and PCBs are substances which require worldwide sanctions if they are to be eliminated or controlled. Because they are extremely persistent chemicals, they are transported throughout the oceans and atmosphere. To put the matter plainly, if PCBs are still disposed of carelessly on a substantial scale in one part of the world, wildlife throughout the world remains in danger. If DDT is banned in the Northern Hemisphere but not in the Southern Hemisphere, the whole world will contine to be affected. In these, and presumably in many other potential situations of a similar character, international solutions are the only effective remedy.

In view of this, it seems neither probable nor even ultimately desirable that individual countries should seek unilaterally to limit the manufacture, importation or disposal of pollutants of this type. Still less can the Monsanto action be expected to become the norm, unless the company concerned has no competitors or potential competitors in the manufacture of the substances concerned. Even a country as large and as powerful as the U.S.A. is vulnerable. It can ban the use of a harmful substance within its border; it can ban the import of the substance from abroad, and it can exert pressure on other countries to take similar measures on a bilateral or multilateral basis. But in so far as the import of

manufactured goods is concerned, how is the U.S.A. to be sure that the substances concerned are absent without elaborate testing of a kind which is practically impossible? How can it prevent those substances from washing up its tidal estuaries or falling in rain from an atmosphere which contains them in similar concentrations through the world?

The questions are posed here, but answers will not be attempted. It seems fairly clear that answers do not at present exist and it is unfortunately also true that insufficient attention has been given up to the present to this type of problem by social scientists, including lawyers. Within the last few years monitoring devices and information systems have been developed by physical and biological scientists, so that the effects of environmental pollution are being recognized and measured and the probable causes identified. The same scientists, however, are usually much less able to offer workable solutions in an imperfect world. If Dean Acheson is right to conclude, at the end of his memoirs, that "The simple truth is that perseverance in good policies is the only avenue to success",[73] it seems essential that the social scientist should contribute to the development of such policies and he will also be required to provide a good deal of the perseverance. The international lawyer surely cannot escape a share of such responsibility here, however difficult it is to define at present.

> In the future, international action concerning environmental management will probably have to go well beyond arrangements for research and information systems. This stems from ..... analysis which shows that, more and more, technological spillovers will be international in dimension. It stems from the corollary that the primary sources of the most significant environmental problems will be found in the design offices, laboratories and

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73. Acheson, D., Present at the Creation, My Years in the State Department, New American Library, New York, 1970, p. 924.

> production lines of foreign or multinational companies and will be most amenable to strategies applied at the national or international level. It stems, too, from the fact that the pollution of air and water resources is increasingly a global phenomenon."[74]

Conclusion

In order to end on an optimistic note, let us return to the more tractable international problems of pollution which exist in North America. The Marine Pollution Bulletin, which is published in the United Kingdom, recently examined the problems involved in attempting to take unilateral action in the amelioration of world problems. It suggested that, although in the last analysis more than this is required,

> Fortunately, certain industries and countries can act as pacemakers. The automobile industry in the United States is a case in point ..... The introduction a year or so ago of new safety regulations in the United States are ..... affecting car design not only in the United States but throughout the world. The same will probably be true of the proposals to reduce air pollution from car exhaust in the United States. Unilateral legislation in other countries has far less international impact..... for effective pollution control we shall have to wait for international agreement or action in the United States.[75]

There are other grounds for optimism that America, and presumably North America, will continue to act as pacemakers. The U.S.A. and Canada may in the Great Lakes have a polluted mess which is better than that of the Rhine only because the Great Lakes require longer to kill. But, although completely effective use has yet to be made of it, there is in the International Joint Commission an instrument capable of initiating the restoration of water quality

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74. MacNeill, Environmental Management, loc. cit., p. 56.

75. Marine Pollution Bulletin, 1, 3, 1970, p. 33.

in the Great Lakes which the countries along the Rhine have yet to develop. Indeed, a process of consultation between Canada and the United States, initiated a year ago, now seems likely to lead to comprehensive joint arrangements to clean up the Great Lakes under the aegis of the International Joint Commission. There are other signs of increasing cooperation between the U.S.A. and Canada. Canadians are sensitive at present about proposals for a continental energy policy, or a continental resources policy. Although this paper can speak neither for the Canadian government nor for the Canadian population, there is reason to believe that both would welcome a strong continental policy for the environment. So far as they can, they are likely to insist on it.