Molina and Rowland conclude that the Earth's atmosphere has only a finite capacity for absorbing chlorine atoms without important consequences. According to their view, the present understanding of atmospheric chlorine chemistry suggests that this absorptive capacity may be insufficient even to cope with the number of Cl atoms equivalent to the quantities of freons at present introduced into the atmosphere on a world-wide scale. More accurate estimates of the absorption capacity are desirable, and no account can be taken of possible heterogeneous reaction between Cl atoms and particulate matter in the stratosphere. If the conclusions of Molina and Rowland are correct, then the effects of the stratospheric photodissociation of CF_2Cl_2 and $CFCl_3$ could not be removed immediately even if no more freons were introduced at ground level. That is because of the postulated long residence time of these species in the lower atmosphere.

The inevitably approximate nature of this type of calculation, and the far reaching assumptions required, should be borne in mind. Discussions such as that of Molina and Rowland, however, serve a most useful purpose in initiating discussion of a new aspect of atmospheric ozone. It is reassuring that interest in these and related problems is being taken by the US Department of Transportation, in its support of the Climatic Impact Assessment Program, under the auspices of which several valuable discussion documents are being issued.

It is conceivable that sulphur dioxide, emitted in relatively large quantities during the combustion of many natural hydrocarbon oils, such as aviation fuel, might also affect ozone concentrations by the photochemical dissociation of SO_2 to SO + O, followed by the reaction of SO with O_3, which has a rate comparable to that of NO with O_3.

This possibility, which requires further consideration, is raised in order to highlight the fragility of the ozone layer and the consequent need for thorough knowledge of the mechanisms and rates of chemical reactions involving ozone.

M. A. A. CLYNE

Phosphorus and the eutrophication problem

SCHINDLER of the Freshwater Institute, Winnipeg, has described in *Science* (**184**, 897–898; 1974) the effects on the growth of planktonic algae of fertilising small, unproductive Canadian lakes with compounds of phosphorus, nitrogen and carbon. If nitrogen or carbon were added there was no marked change in the phytoplankton. If phosphorus was added as well or by itself, there were large increases in phytoplankton. When the additions of phosphorus were discontinued the phytoplankton soon returned to the pre-fertilisation levels. Hence Schindler concludes that a large decrease in the phosphorus content of sewage effluents is the essential remedy for the over-enrichment of waters by man or, as it is called, cultural eutrophication. Polyphosphates in detergents should be banned since they form some 50% of sewage phosphorus (somewhat less in Britain). He agrees with those people who advocate the chemical treatment of sewage to remove a substantial amount of all waste phosphorus. But rapid action is needed and the removal of polyphosphates from detergents will meet this need.

Nearly all limnologists who have investigated the problem will agree with Schindler that phosphorus is a major cause of eutrophication. He refers to several lakes which have benefited from the removal of sewage effluents but it is less clear whether the removal of detergent phosphorus alone would have prevented undesirable eutrophication. Some action has been taken. Canada has prohibited the sale of detergents containing more than 2.2% of phosphorus and some American States have passed similar legislation (see Schindler's article); others will remove phosphorus by sewage treatment.

If polyphosphates are to be removed from detergents, in which they play a vital part, what is to replace them? At present there is no generally agreed answer. In Canada nitrilotriacetic acid (NTA) is a permitted alternative. A governmental warning against its use, has, however, been issued in the United States (see statements by Environmental Protection Agency Administrator and Surgeon General (December 18, 1970) and by Chairman, Committee on Public Works, US Senate (December 19, 1970)). As a result substances such as washing soda and sodium silicate have been used and the detergents containing them are said to be of poor quality, as may be expected. Experience of the world-wide use of several organic compounds suggests that extensive and intensive tests are necessary before they are accepted as safe. Phosphates, though bad for eutrophication are otherwise harmless. One must also realise that any increased cost of a replacement will be passed on to the consumer. It seems therefore that there are arguments for and against Schindler's viewpoint.

European experience supports Schindler's view that phosphates are the commonest major cause of cultural eutrophication and that nitrogenous substances are the next most important cause (Vollenweider, OECD Report DAS/CS1/68.27; 1968). Observations for more than 30 years and experiments with large enclosures in the English Lake District (Lund, *Proc. R. Soc.*, **B180**, 371–382; 1972; *Verh. int. Verein. theor. angew. Limnol.*, **18**, 71–77; 1972 and unpublished data) have also shown that phosphorus is an important factor in eutrophication, though it is an over-simplification to blame everything on one element. The same is likely to be true in other British waters.

The UK Standing Committee on Synthetic Detergents (12th Progress Report, HMSO; 1971) is against the present use of NTA and does not consider that phosphorus removal is as yet justified. Nevertheless its reduction from sewage before it enters the already eutrophic Lough Neagh, Northern Ireland has been advocated (Wood and Gibson, *Water Res.*, **7**, 173–187; 1973). Schindler says that the removal of phosphorus from sewage "while fine in principle . . . will take several years to implement to any effective degree, considering the time lags and uncertainty inevitable in financing, planning and constructing such facilities". Sweden and Switzerland, however, have gone ahead vigorously with just such a scheme; other countries are doing so or preparing to do so to various extents. In Sweden, in particular, it seems that an added gain is a general improvement in the final effluent.

The eutrophication problem is not the same everywhere. It is doubtful whether the best remedy for one lake or lake region is the best for all. Phosphate enrichment may produce unwanted changes in one lake but will not do so in other lakes. Moreover, opinions differ about which substances are the most harmful. It seems reasonable that each lake or lake area should be considered separately, bearing in mind the general, though still imperfect, knowledge of eutrophication. Then it can be decided whether remedial measures are necessary, what they might be, whether they are acceptable on economic or other grounds and whether legislation is necessary to implement them.

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