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Letters to the Editor

THE ASSESSMENT OF MAJOR HAZARDS: THE LETHAL TOXICITY OF BROMINE, by R.M.J. WITHERS and F.P. LEES (*Journal of Hazardous Materials*, 13 (1986) 279–299)

Comments by P.C. Davies and G. Purdy*

The basis of this paper is the assertion that the lethal toxicity of bromine may be derived from that for chlorine (derived by Withers and Lees in an earlier paper [1] together with the assumption (based on the work of Schlagbauer and Henschler [2] that bromine is 1.5 times less toxic than chlorine. We suggest that this approach neglects the absolute data on the toxicity of bromine and other information on the effects of bromine.

Schlagbauer and Henschler state that "the lethal dose (the LC_{50}) for bromine is 1.5 times that for chlorine". They also present LC_{50} values for bromine, for an exposure time of 30 min, using mice, namely 196 and 174 ppm for observation periods of 4 and 10 days, respectively. These values contrast with the value derived by Withers and Lees of 375 ppm for a regular (i.e. the *less* vulnerable) population of humans at the standard level of activity. It should also be noted that the lowest concentration found to be lethal for a 30 min exposure to bromine is Schlagbauer and Henschler's value of 62 ppm, and that this is the *same* value as they give for chlorine for the same species, mice. We question whether it is reasonable to accept Schlagbauer and Henschler's statement on relative toxicity without also taking account of their data on absolute toxicity.

Furthermore, in our opinion, Withers and Lees do not take sufficient account of the findings of a number of workers which suggest that bromine acts differently from chlorine and has more severe effects. For example, Hill [3] and Symes [4] are mentioned by Withers and Lees as describing specific severe effects of bromine, and the work of Bitron and Aharonson [5] shows (via the delayed mortality effects) that there are substantial differences in the effects of chlorine and bromine. Indeed, at the end of their own discussion on the physiological and pathological aspects, Withers and Lees state that, "it may be expected, therefore, that asphyxiation due to damage to, and blockage of, the respiratory tract will be a more serious hazard with bromine than with chlorine".

The data of Schlagbauer and Henschler were obtained with mice. Withers and Lees argue that the LC_{50} values for mice are almost certainly less than for

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larger animals; they previously used this argument to justify giving more weight to the data of Underhill [6] on dogs in their derivation of chlorine toxicity levels. However, man may actually be much more similar to rodents than larger test animals in his response to toxic irritant gases – see Engelhardt and Holliday [7]. Thus, Withers and Lees' previous use of Underhill's dog data for chlorine toxicological criteria for man, may by their approach lead to an artificially high value for bromine.

The authors themselves state that the information available on bromine is more sparse than that on chlorine. We agree, but taking all the factors referred to above into account it is our view that a more cautious approach should have been adopted, and until further evidence is available we suggest that the toxicity of bromine should not be assumed to be less than that of chlorine.

We would also point out that relationships of the type produced in this paper may not be appropriate for risk assessments for town and country planning purposes. See Davies and Hymes [8] for a discussion of this aspect in relation to chlorine. Similar arguments would apply for bromine.

References

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Reply by R.M.J. Withers and F.P. Lees

In our review of the LC_{50} for 30 min for chlorine we found values of 256, 414 and 650 ppm for mice, rats and dogs, respectively. We took a value for man of 500 ppm for the base level of activity and of 250 ppm for the standard level. The value for mice was an average value which included the value of 127 ppm obtained by Schlagbauer and Henschler. Equivalent data for bromine are not available, but the values of 196 and 174 ppm obtained by Schlagbauer and

Henschler for mice for bromine with 4 and 10 day observation periods, respectively, are consistent with our proposal that the LC_{50} for bromine be taken as 1.5 times that for chlorine. This factor of 1.5 is not based solely on the statement or data of Schlagbauer and Henschler, however, but takes into account the other work described such as that of Bitron and Aharonson.

With regard to the lowest concentration found to be lethal to mice in the work of Schlagbauer and Henschler, we do not attach much importance to the fact that this is the same for chlorine and bromine. It refers to a single death in each case. We regard its significance as limited to giving a minimum concentration at which a death occurred.

Bromine attacks not only the lungs but also the respiratory tract. The literature gives some striking examples of this latter effect. It does not follow, however, that this is the main cause of death. The large proportion of late deaths recorded by Schlagbauer and Henschler and by Bitron and Aharonson argues against this and points to lung oedema. Nor does it follow that bromine is more lethal than, or as lethal as, chlorine. Ammonia causes death by attacking the respiratory tract, but it is less lethal than chlorine.

The work of Engelhardt and Holliday is concerned with the toxicity of ammonia and, in this context, with susceptibility of species to attack of the respiratory tract. Since we believe this is not the prime mode of attack for bromine, it follows that we do not believe that this affects our models for chlorine and bromine toxicity. For further comments on the toxicity of ammonia we refer the reader to the report of the Toxicity Working Party of the Major Hazards Advisory Panel [1].

We would like to reiterate that the toxicity models which we have given are intended to be realistic rather than conservative. Indeed, at several points in our work we had to remind ourselves that it was realistic rather than conservative values which we sought. We believe that risk assessments should be realistic rather than conservative, but should also indicate the degree of uncertainty.

It is proper, however, that regulatory authorities should take a cautious approach and in applying toxicity values should use a degree of conservatism which is appropriate to the scale of the hazard and to the nature of the data available. The data for bromine are sparse, which reinforces the need for caution. For example, we would regard the differences in lethal toxicity for chlorine and for bromine in our work as not very significant in relation to decision-making on land use planning.

References

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