GASES, TOTAL DISSOLVED

EPA Criterion

To protect freshwater and marine aquatic life, the total dissolved gas concentrations in water should not exceed 110 percent of the saturation value for gases at the existing atmospheric and hydrostatic pressures.

Reviewers: W.J. Ebel (Coordinator), K.T. Beiningen, G.R. Bouck, W.R. Penrose, and D.E. Weitkamp

I. Criterion

The criterion is expressed in terms of percentage saturation of total dissolved gases, however, it lacks adequate definition for its calculation and measurement. For example, within the body of this section it should be stated whether or not to include water vapor pressure. In addition, nothing is said about location of measurement or whether a single sample or a weekly or monthly average is to be used. The criterion also omits clarification of allowable time or duration of supersaturation, as well as whether the criterion is an instantaneous maximum at any point or the final product of a mixing zone. The use of physical pressure units are the standard both in underwater physiology and in engineering, hence their equivalent should be included in the criterion, if only in parenthesis. Although the use of pressure units is not immediately essential, they should be included to prepare the reader for their usage.

Two separate criteria are needed: one for open or natural aquatic environments, and a second for waters which hatcheries or aquaria receive. It is known that 110 percent saturation is too high for developing yolk sac fry when they are in shallow hatchery troughs (Woods 1974), whereas 110 percent would be sufficiently low to protect aquatic organisms in the freshwater environment where water depth would be sufficient to compensate for 110 percent saturation. The work of Marsh and Gorham (1905) was done at least in part in saltwater aquaria.

The deficiencies noted in the criterion can be corrected if two or more criteria are proposed such as the following:

1. For receiving waters in hatcheries or aquaria where fish are restricted to less than 60 cm of water depth, the total gas pressure shall be less than 105 percent of air saturation (less than 40 mm Hg hyperbaric or equivalent pressure units) excluding water vapor pressure.
2. For freshwater and marine environments, three members of the panel felt that the total gas pressure should not exceed 115 percent of air saturation (less than 114 mm Hg or equivalent pressure units) excluding water vapor pressure. Two members of the panel felt that the total gas pressure should not exceed 110 percent air saturation (less than 80 mm Hg or equivalent pressure units) excluding water vapor pressure.

3. The standard method of measuring dissolved gas pressure should be via the Weiss Saturometer as described by Fickeisen et al. (1975) or any other method with equal or better capability.

II. Rationale

There is no heading indicating an "Introduction" in the Red Book but the section entitled "Rationale" adequately introduced the subject. The background information is correct and relevant, but some pertinent additional information should be referenced.

There are three additional ways in which supersaturation can occur. They are:

1. Natural waterfalls with deep plunge basins can cause supersaturation and subsequent adverse effects to fish (Harvey and Cooper 1962).

2. The use of air in turbine intakes to avoid cavitation creates supersaturation—a condition that can be avoided if identified (McDonald and Hyatt 1973).

3. Venturi action caused by improper engineering of hatchery water supplies has also been described by Harvey and Smith (1961), Wyatt and Beiningen (1971), and Rucker and Tuttle (1948).

The Rationale section does make a case for the criterion presented, but it also indicates that perhaps the maximum allowable level could be higher for natural freshwater environments where anadromous salmonids are the primary species present. The reviewers therefor could visualize situations where the gas level could be allowed to exceed the criterion of 110 percent if adequate justification could be provided. To enforce stringently the 110 percent standard for all situations and conditions, particularly in areas where depth compensation is known to be a factor, would be wrong, and could do more harm than good.

There are several other literature citations which should be referenced. Fickeisen, et al. (1975) evaluated the Weiss saturometer. Beiningen (1973) also has written an up-to-date manual for determining gas concentrations in water using a version of the Van Slyke-Neill apparatus. This reference would be particularly useful to the scientists who are inexperienced in nitrogen gas analysis.

The effect of stress level concentrations and exposures is not mentioned. Schieve (1974) reported on the effects of sublethal exposure.
Normal or background levels or fluctuation ranges are also not mentioned; some mention of these should be made with appropriate literature citations.

The preferred method of analysis is not mentioned; if EPA has one, it should be specified.

Synergism is not recognized. Increasing temperatures that occur when the water is supersaturated accelerate the adverse effects of supersaturated water (Ebel et al. 1971; Coutant and Genoway 1968).

The deficiencies of knowledge are adequately provided for by a safety factor if 110 percent is established as a standard, but the point made earlier regarding enforcement of this standard under all conditions stands.

III. References Cited

Most literature references were correct and appropriately cited. Errors noted, however, were the misspelling of Lindroth (page 71), and the incorrect listing of Dawley and Ebel (1975). Ebel (1969) should be referenced; it is a more recent publication which supports Lindroth (1957). The unpublished report by Dawley et al. (1975) has now been superseded by Dawley et al. (1976). Ebel and Raymond (1976) supersedes Ebel et al. (1975).

With regard to selection of references cited, the review panel noted that of the 18 references, only eight of these have appeared in refereed journals; four are privately published reports not easily available to the scientific community, two were presented at symposia, and three are unpublished reports. The remaining reference was the NAS Blue Book. The literature is more extensive than the Red Book might lead the uninitiated to believe. Particularly unfortunate is the omission of reference to the article by Harvey (1975); the more recent review by Weitkamp and Katz (1977) should also be referenced in a future criteria document. Other useful references are listed below.

IV. Reviewers' Discussion

The reviewers were in general agreement regarding suggestions and criticisms throughout the various sections of this review except for the specific criteria for percent air saturation for freshwater and marine environments.

One reviewer believes that existing knowledge is adequate to predict that the effects of supersaturation in salt water do not differ from those described for freshwater. The remainder of the reviewers believe insufficient data are available to make an adequate prediction, although they do not necessarily feel the above prediction is in error. None of the reviewers produced any information to indicate a significant difference in the effects of supersaturation in salt water as compared to freshwater.

Some of the reviewers believe that a dissolved gas criterion of 115
or 120 percent would be adequate to protect freshwater and marine biota in most waters. Other reviewers favor the 110 percent criterion. The expressed opinions of the reviewers indicate a dissolved gas criterion could be established at 110, 115, or 120 percent with arguments favoring selection of any of these figures.

V. Recommendations for Improvement of this Section

There are three main points that should be addressed and discussed:

1. 110 percent saturation is not safe for hatchery or aquarium water supplies where juvenile salmonids or other sensitive organisms might be reared in shallow water.

2. 110 percent saturation is too high to enforce stringently in situations where anadromous salmonids are provided depth compensation of one or more meters, particularly when exposure times would be limited to less than 30 days.

3. There are deficiencies in the data regarding effects of supersaturation on marine organisms; even though the data available suggest that there is little difference in the tolerances between marine and freshwater species, it would be very difficult to enforce a 110 percent standard for marine organisms unless more supportive data are available.

Literature Cited


Other Useful References


