

COMMENTS ON THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY'S PROPOSAL TO ADD AMMONIA TO THE TOXIC POLLUTANT LIST

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1. Introduction

In the January 3, 1980 *Federal Register*, the U.S. EPA published 'Toxic Pollutant List: Proposal to Add Ammonia', (U.S. EPA, 1980) in which an attempt was made to propose and justify the addition of ammonia to the Toxic Pollutant List. In the opinion of the authors, the inclusion of ammonia on this list would be inappropriate. Justification for this position is presented below.

2. Implications of and Problems with Proposed U.S. EPA Action

First and foremost, the Toxic Pollutant List should be restricted to those chemicals which, because of their persistence and environmental impact, represent widespread, generally significant environmental hazards when discharged to the environment. An example of this type of chemical would be PCBs. Chemicals such as ammonia, whose impact on water quality is a local problem of concern primarily to the residents-users of the region in which the discharge takes place, should not be included on the Toxic Pollutant List.

As noted in the *Federal Register* discussion of this proposal, if ammonia is placed on the Toxic Pollutant List, the U.S. EPA could, should it choose to do so, establish a fixed numeric limit on the *total* ammonia content of the discharge from any source to aquatic systems. Further, listing ammonia as a 'Toxic Pollutant' would permit the U.S. EPA to forbid municipalities, other governmental agencies, industry, agricultural interests, etc., from giving consideration to economic impacts in their development of ammonia control programs. There are a number of significant problems with the fixed numeric standard approach for total ammonia. As noted in the *Federal Register* (U.S. EPA, 1980), the environmental chemistry of ammonia is such that the same total ammonia concentrations can have considerably different toxicities depending on other characteristics of the receiving water (such as pH and temperature). Unless the total ammonia standard is set at worst-case levels, there would be no guarantee that a total ammonia effluent standard will provide adequate environmental protection in all cases. This situation could readily result in many municipalities, industries, agricultural interests

and others spending large amounts of money for the development of ammonia control programs to achieve the arbitrarily established effluent limitation, with little or no discernible impact on the water quality in terms of beneficial uses to man, of the waters receiving the ammonia discharges, beyond that achievable using a less conservative but technically valid basis for standard. The adoption of the proposed U.S. EPA action could readily cost the taxpayers and consumers of the U.S. very large amounts of money with, in many instances, no improvement in water quality.

There is also a procedural matter that should be addressed in connection with this proposal by the U.S. EPA. The U.S. EPA is not divulging to the public its intentions in initiating this rule-making proposal. The discussion presented in this *Federal Register* leaves the public confused as to the U.S. EPA's ultimate plan to deal with ammonia. In order that the public can properly evaluate the full consequence of the addition of this chemical to this list, the U.S. EPA should have, prior to proposing to add this chemical to this list, made known its complete position with respect to ammonia. If the U.S. EPA has not developed its position, then it certainly should do so before any further action is taken on this matter. Its position should be reviewed at the same time as the proposal to add ammonia to the Toxic Pollutant List. If the U.S. EPA feels that it is necessary to impose an effluent standard on total ammonia concentration, then it should present justification for this approach and indicate the magnitude of the value that it proposes to set as this standard. In this way, municipalities, industry, agri-business, and others could fully evaluate what this proposed action would mean to them. While the original 'List of 65' was hastily prepared by a limited number of individuals and was not properly reviewed by the water quality control technical community as a whole, there is no justification to hastily consider the addition of other compounds such as ammonia to this list.

There is absolutely no justification for singling out ammonia as needing a universal, ultraconservative approach for the development of control programs. The environmental behavior of ammonia and its aquatic toxicology have been extensively studied and are fairly well known. The reviews by the NAS-NAE (1973), U.S. EPA (1976), Thurston *et al.* (1979), and Thurston and Russo (1979) provide detailed discussion of the state of knowledge on the toxicity of ammonia to aquatic life. The extent of ammonia persistence in aquatic systems has been extensively investigated for many municipalities and industries as part of developing waste load allocations for oxygen demanding materials, in accord with the provisions of PL 92-500 (208 planning activities of the late 1970s). As part of this effort, a variety of mathematical models has been developed which can be used, when calibrated to a specific site, to predict the extent of persistence in a particular water, of ammonia from a particular source. While the focal point of these modeling efforts has been protection of the oxygen resources of the receiving waters, they are equally applicable to predicting the extent of the receiving waters that is toxic to aquatic life due to un-ionized ammonia. One such model, developed by Bauer *et al.* (1979) of the USGS, has been found by the author to be particularly useful for this purpose. For a general description of the use of these types of models, see the textbook by Eckenfelder (1980).

As noted in the *Federal Register*, ammonia is a non-persistent, non-bioaccumulating chemical which is present in a wide variety of sources of contaminants for aquatic systems. Further, while the U.S. EPA does not indicate in the January 3, 1980 *Federal Register* what total ammonia effluent limitation it might select should this action be approved, it is conceivable that a wide variety of natural sources of ammonia could have concentrations of ammonia exceeding the effluent numeric value. For example, work done by the Canada Centre for Inland Waters has shown that precipitation can be a prominent source of ammonia for surface waters. Milligram per litre levels of total ammonia were found in drainage from Wisconsin marshes by Lee *et al.* (1975) and Bentley (1969). Storm-induced suspension of sediments in lakes, rivers, coastal and estuarine waters could also result in elevated ammonia concentrations in natural waters. In studies by Lee *et al.* (1978) and Jones and Lee (1978) on dredging – dredged sediment disposal in an estuary in Florida, the suspension of the sediments into the overlying waters was found to result in ammonia concentrations as high as 9 mg l^{-1} as N. There were no pollutional sources of ammonia or other nitrogen compounds for that particular area. This was naturally-derived ammonia such as is derived from the sediments of many natural waters. While dredging of these sediments for maintenance of navigable channel depth resulted in milligrams per liter of ammonia being present in the dredged sediment receiving waters, because of the rapid dilution and the fact that aquatic organisms can tolerate relatively large concentrations of ammonia for short periods of time compared to the chronic safe limit or lifetime exposure safe level (Lee *et al.*, 1978; Jones and Lee, 1978), there were no detectable or expected deleterious effects of discharging this water through dredging operations into the areas adjacent to the navigation channel. Leaching test bioassays conducted by Lee *et al.* (1978) on waterway sediments from across the country showed that while up to 10 mg N l^{-1} total ammonia was present in the bioassay waters (5 to 20% dredged sediment), typically mortality ranged from 0 to 20% in 96 h. It should be noted that in many areas, normal use and storm events suspend large quantities of sediment into the water column creating turbidity conditions similar to those of dredging-disposal. While the U.S. EPA might be able, because of legal provisions, to issue an exemption for dredged sediment discharges, it would certainly be difficult with a rigid ammonia effluent standard in effect, to exempt a municipality, industry, or other source which might be discharging several milligrams per liter of ammonia, even where, because of the dilution, temperature, and pH of the receiving waters, there would be no toxicity of ammonia to aquatic life. Further, rarely could standards be imposed on natural sources such as storm-induced sediment suspension, precipitation, etc.

The justification – 'information' provided in the *Federal Register* for including ammonia on the Toxic Pollutant List is not a proper appraisal of the impact of ammonia on water quality. It is focused largely on chronic toxicity with some acute toxicity information on un-ionized ammonia and nitrite. There is no indication given as to the relationship between these laboratory test results and actual water quality problems caused by the presence of ammonia or nitrite in natural waters of the U.S., present due to either natural or anthropogenic sources. Further, one of the most significant impacts

of total ammonia on water quality relates to its being an aquatic plant nutrient. This topic was not addressed in the January 3 *Federal Register*. The levels at which ammonia can stimulate excessive amounts of aquatic plant growth (with nitrate, about 0.3 mg N l^{-1} (Lee, 1973)) are well below those concentrations of total ammonia which would generally be toxic to aquatic organisms. Since the major impact of ammonia on aquatic plant growth is restricted to the relatively small number of waterbodies in which aquatic plant growth is nitrogen limited, it would be technically inappropriate to set the total ammonia effluent standard at levels which would not cause stimulation of excessive growths of aquatic plants. Yet, this is a significant potential impact of ammonia on water quality which cannot be ignored. This situation points again to the necessity of evaluating the water quality significance of the discharge of ammonia on a case-by-case basis. Toxicity testing alone would not flag the stimulatory impact of ammonia. In a U.S. EPA report, Rast and Lee (1978) discussed the relative significance of nitrogen as a cause of eutrophication-related water quality problems in the U.S.

Another related problem with the justification – 'information' section of the U.S. EPA's proposal (U.S. EPA, 1980), is that a major information component needed to assess the hazard of ammonia to water quality was not discussed. As pointed out in a subsequent section of this report, equally important as toxicological information in making this hazard assessment, is the environmental chemistry-fate of ammonia in aquatic systems.

3. Environmental Chemistry of Ammonia

Ammonia is used by many aquatic organisms, is lost to the atmosphere through volatilization, and, most importantly, transformed by microbial action to nitrite and nitrate. The portion of the total ammonia which is in the toxic NH_3 form is governed by the pH, temperature, and dissolved solids content of the receiving waters (U.S. EPA 1976).

The environmental chemistry of ammonia in aquatic systems is such that, based on the experience of the authors, ammonia rarely causes widespread significant adverse effects on water quality. In general, the rate of ammonia production from protein and other nitrogen-containing material (natural sources) is slow compared to its rates of dispersion-transformation (Brezonik, 1967). Brezonik, under the supervision of the principal author, conducted a comprehensive literature review and extensive field studies on the transformation of nitrogenous compounds in aquatic systems with particular reference to ammonia. The load of ammonia added to aquatic systems as a result of activities of man is also, in most cases, rapidly diluted and transformed to chemical forms which have limited or no adverse impact on water quality. A demonstration of this was provided by the results of a million dollar, five-year study conducted by Lee *et al.* (1978) and Jones and Lee (1978), which involved collection and analysis of water samples from about 40 different harbor, waterway, and offshore waters in the U.S. Study sites included several locations in the San Francisco Bay, CA, area; Los Angeles Harbor; New England (Newport, RI, and Stamford, CT); Apalachicola, FL;

Upper Mississippi River near St. Paul, MN; James River, VA; Houston-Galveston, Corpus Christi, TX; Seattle, WA; New York-New Jersey harbors; Mobile Bay, AL; Menominee River, MI-WI; Wilmington, NC; WES Lake, Vicksburg, MS; and the Hudson River, NY. While the focus of this study was the impact of dredged sediment-associated contaminants on watercolumn water quality, it provided a sizeable data base on concentrations of ammonia in U.S. waterways, especially those receiving substantial ammonia-containing industrial and municipal wastewater discharges. The results of these studies, which were published in a 1600 page report by the U.S. Army Corps of Engineers (Lee *et al.*, 1978; Jones and Lee, 1978), showed that in only three areas (two in the Houston-Galveston, TX, area; the other in the Upper Mississippi River) was the un-ionized ammonia concentration greater than the U.S. EPA 0.02 mg/l NH_3 chronic safe criterion (U.S. EPA, 1976). These results demonstrate the rapid dilution-transformation of ammonia and cause serious questions to be raised about the extent of occurrence of water quality deterioration due to ammonia.

In connection with this review of the water quality significance of ammonia, the authors recently contacted the President's Council on Environmental Quality (CEQ), which has the responsibility for conducting annual reviews of the water quality significance of various contaminants and their concentration trends in U.S. waters, to determine if they had conducted any studies on the significance of ammonia as a cause of water quality deterioration. According to D. Burmaster of the CEQ staff, the Council on Environmental Quality has not studied ammonia. The implication of this is that they have not considered ammonia to be of sufficient national concern to rate a high priority for their consideration.

There are situations where ammonia is introduced at a sufficient rate, and characteristics of the receiving waters are such that ammonia can cause significant water quality deterioration near its point of entry. For example, there are stretches of the Poudre and Arkansas Rivers downstream of the Colorado cities of Fort Collins and Pueblo's domestic wastewater discharges where un-ionized ammonia concentrations are above the chronic safe levels cited in the U.S. EPA Red Book. This means that if a fish spent a substantial portion of its lifetime in these areas, it could be harmed because of the ammonia present. This would be expected with many municipal and industrial discharges. Based on the experience of the authors, however, the frequency and expanse of these situations are insufficient to warrant development of a national effluent standard for total ammonia. As demonstrated by the current work of the authors in connection with Fort Collins' and Pueblo's domestic wastewater discharges, which involve instream fish bioassays, fish can spend considerable periods of time – days to weeks – in areas containing elevated un-ionized ammonia concentrations without acute lethal effects. This confirms what has been found in the literature.

Instead of trying to develop a national total ammonia effluent standard, a hazard assessment approach such as that outlined by Lee *et al.* (1979b) should be followed to assess the potential impact of each potentially significant source of ammonia to the waterbody of concern. It would then be possible to develop, on a site specific basis, the most cost-effective ammonia control strategy to achieve the desired water quality

in the receiving waters. The use of a blanket, worst-case approach for ammonia control is neither technically nor environmentally justifiable, and would be highly wasteful of energy and financial resources.

4. Recommended Approach

Since ammonia-related water quality problems are local problems primarily affecting the residents-users of a specific region, the U.S. EPA should follow the approach advocated in Public Law 92-500, i.e., ensuring that appropriate water quality standards based on the societally-designated use of the water, are developed for ammonia; and for those waters which are 'water quality limited', establishing ammonia load allocations to achieve the desired water characteristics commensurate with the designated use of the water.

It is important to emphasize as has been pointed out by Lee *et al.* (1979a), that water quality should not be judged based on the presence of certain concentrations of chemicals in a water, but should, in accord with the provisions of PL 92-500, focus on attaining 'swimmable, fishable' waters; the impact of chemical contaminants should be judged in terms of their effects on the beneficial uses of water by man. Far too often, the U.S. EPA and some state pollution control agencies use administratively simple, but technically unreliable, approaches of trying to assess water quality based on measurements of total concentrations of contaminants in a particular waterbody (Lee *et al.*, 1979a). As discussed by Lee *et al.* (1979b), chemicals exist in aquatic systems in a wide variety of forms, only some of which are available to affect water quality. Further, their concentrations, especially near a source, change rapidly with time and distance, making it unlikely in many cases that fish and other aquatic organisms present in the water column will receive chronic-lifetime exposures to chemicals discharged from the particular source. Not only worst-case – chronic exposure conditions should be considered, but also the fact that near the point of discharge, the ammonia concentration can be elevated considerably above the chronic exposure safe concentration (a few hundredths of a microgram per liter for various types of sensitive fish), without significant detrimental effects on water quality because exposure duration is insufficient to cause toxicity. Also meriting consideration is the fact that in some areas where elevated ammonia levels may be found in waters, other factors, such as substrate type, temperature, and flow, may preclude the existence of more sensitive species.

Instead of using an arbitrary, worst-case approach for ammonia, a hazard assessment approach such as that outlined by Lee *et al.* (1979b) should be used to develop technically valid, cost-effective, and environmentally protective standards and control programs for ammonia, on a site-by-site basis. The hazard assessment approach is based on evaluation of both aquatic toxicology and environmental chemistry-fate information. These factors must be considered in the assessment of the appropriateness of any effluent limitation to ensure not only cost-effectiveness, but also environmental protection. All of the problems cited in the January 3 *Federal Register* as justification

– 'information' for adding ammonia to the Toxic Pollutant List, could be regulated much more effectively by such a case-by-case approach. For example, the January 3 *Federal Register* attempts to justify its proposal because of '... temporary, but highly toxic, surges of ammonia'. Actually, it is partially because of this situation that the U.S. EPA approach is not appropriate; as indicated earlier, many organisms of concern can tolerate high concentrations of contaminants including ammonia for short periods of time, without experiencing significant adverse effects. In developing control programs for ammonia, consideration must be given not only to the aquatic toxicology for chronic – lifetime exposure, but also the concentration – duration of exposure to available forms – toxicity relationships and the environmental chemistry-fate of ammonia and its transformation products in the system of concern.

Control programs must focus on available forms of contaminants that occur in a particular source or that will arise within a waterbody because of the introduction of a particular source of chemicals. Failure to follow this approach will certainly lead to the taxpayers and consumers of the U.S. spending large amounts of money in the name of water pollution control, without there being a concomitant benefit in beneficial uses of a water to the residents-users of a region. It should be noted that it would be rare that decreases made in the load of ammonia in one area alone would result in downstream users of the water achieving significant improvements in water quality. Even some of the most significant environmental contaminants, such as PCBs, manifest their impact to the greatest extent near their points of entry to the environment (Lee and Jones, 1979).

5. Additional Considerations

Rather than attempting to add chemicals like ammonia to the Toxic Pollutant List, the U.S. EPA should be vigorously working toward removing a number of chemicals on this list that can be readily controlled through conventional pollution control programs mandated in PL 92-500 or the 1977 amendments thereof. There is no need, and in some cases it is technically inappropriate, to impose fixed numeric effluent standards for most of the chemicals that are on the Toxic Pollutant List at this time. That list, it should be recalled, was not developed based on a consensus of the water quality control technical community who had been working on the significance of contaminants in aquatic systems for many years. It was somewhat hastily developed under a court order, by a number of individuals, many of whom had had limited experience in evaluating the significance of chemical contaminants in aquatic systems. It was not properly reviewed by the water quality control technical community. It is the opinion of the authors and others that many of the chemicals on this list should be removed because of inappropriate categorization.

There are a number of professionals in the water pollution control field who have devoted a considerable part of their careers to evaluating the significance of chemical contaminants to water quality (such as the authors) who feel that the promulgation of the 'List of 65' as it was developed has done significant harm to water pollution control

efforts within the United States as the result of giving disproportionate attention to a large number of chemicals which are relatively unimportant as causes of water quality deterioration in the U.S. and almost completely shutting down all research and development work on the classical pollutants. Topics such as the real difference to water quality between a minimum dissolved oxygen concentration of 4 mg l⁻¹ in a river and 5 mg l⁻¹, deserve much greater attention than most of the exotic chemicals on the Toxic Pollutant List. Rather than adding another chemical such as ammonia to this list, the U.S. EPA should be focusing on working with states, municipalities, industry, and others in helping evaluate the actual impact of ammonia discharges on beneficial uses of a water in a particular region, so that the municipalities or residents-users of the region can decide the appropriate degree of treatment for removal of ammonia from a particular source.

States (such as Ohio), cities, industry, and governmental agencies, the President's Council on Wage and Price Stability, etc., have criticized the Office of Water Planning and Standards of the U.S. EPA's Criteria and Standards Division for inappropriate approaches for implementing the provisions of PL 92-500. The U.S. EPA should critically examine its overall philosophy of approach. If this were done, it would undoubtedly be concluded that there is no justification for listing ammonia as a member of the Toxic Pollutant List.

References

- Bauer, D. P., Jennings, M. E., and Miller, J. E.: 1979, 'One-Dimensional Study - State Stream Water Quality Model', U.S. Geological Survey Water Resources Investigations 79-45, USGS NSTL Station, MS.
- Bentley, E.: 1969, *The Effect of Marshes on Water Quality*, Ph.D. Dissertation, Univ. of Wisconsin-Madison, Water Chemistry.
- Brezonik, P.: 1967, *The Dynamics of the Nitrogen Cycle in Natural Waters*, Ph.D. Dissertation, Univ. of Wisconsin-Madison, Water Chemistry.
- Eckenfelder, W. W., Jr.: 1980, *Principles of Water Quality Management*, CBI Publishing Co., Boston.
- Jones, R. A. and Lee, G. F.: 1978, 'Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open Water Disposal of Dredged Sediment, and Environmental Impact of Open Water Dredged Material Disposal', Vol. I: Discussion, Technical Report D-78-45, U.S. Army Corps of Engineers WES, Vicksburg, MS.
- Lee, G. F.: 1973, 'Eutrophication', Transactions of the Northeast Fish and Wildlife Conference, pp. 39-60.
- Lee, G. F. and Jones, R. A.: 1979, 'Significance of PCBs in Dredged Sediment', Final Report to U.S. Army Engineer Waterways Experiment Station. To be published by U.S. Army Engineer WES, Vicksburg, MS.
- Lee, G. F., Bentley, E., and Amundson, R.: 1975, 'Effect of Marshes on Water Quality', in *Ecological Studies 10, Coupling of Land and Water Systems*, Springer-Verlag, New York, pp. 105-127.
- Lee, G. F., Jones, R. A., Saleh, F. Y., Mariani, G. M., Homer, D. H., Butler, J. S., and Bandyopadhyay, P.: 1978, 'Evaluation of the Elutriate Test as a Method of Predicting Contaminant Release during Open Water Disposal of Dredged Sediment and Environmental Impact of Open Water Dredged Material Disposal', Vol. II: Data Report, Technical Report D-78-45, U.S. Army Corps of Engineers WES, Vicksburg, MS, 1186 pp.
- Lee, G. F., Jones, R. A., and Newbry, B. W.: 1979a, 'Water Quality Standards and Water Quality', Accepted for publication. Journal Water Pollution Control Federation.
- Lee, G. F., Jones, R. A., and Newbry, B. W.: 1979b, 'An Environmental Hazard Assessment Approach for Water Quality Management', Occasional Paper No. 46, Department of Civil Engineering, Environmental Engineering Program, Colorado State University, Fort Collins, CO.
- National Academy of Science and National of Engineering (NAS-NAE): 1973, Water Quality Criteria - 1972, EPA R3 73-033, U.S. Gov't. Printing Office, Washington, D.C. (1973).

- Rast, W. and Lee, G. F.: 1978, 'Summary Analysis of the North American (U.S. Portion) OECD Eutrophication Project: Nutrient Loading-Lake Response Relationships and Trophic State Indices', Report EPA-Corvallis. EPA 600/3-78-008.
- Thurston, R. V. and Russo, R. C.: 1979, 'Some Factors Affecting the Toxicity of Ammonia - Implications for Water Quality Standards', Presented at American Water Resources Association Symposium on the Use of Scientific Information in Planning for Environmental Quality Objectives, To be published in Symposium Proceedings.
- Thurston, R. V., Russo, R. C., Fetterolf, C. M., Jr., Edsall, T. A., and Barber, Y. M., Jr.: 1979, *A Review of the U.S. EPA Red Book: Quality Criteria for Water*, Water Quality Section, American Fisheries Society, Bethesda, MD.
- U.S. EPA: 1976, *Quality Criteria for Water*, EPA-440/9-76-023, U.S. EPA Washington, D.C.
- U.S. EPA: 1980, 'Toxic Pollutant List: Proposal to Add Ammonia', *Federal Register*, (40 CFR Part 401, FRL 1383-6) 45(2): 803-806, Jan. 3.

Subsequent to completion of this paper, the U.S. EPA has withdrawn its proposal to add ammonia to the Toxic Pollutant List.