Virginia Water Resources Research Center
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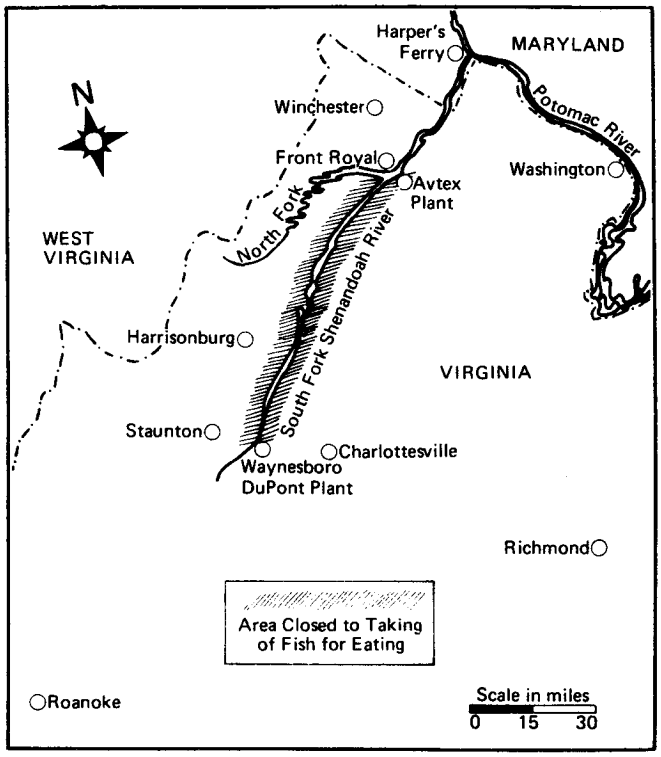
Mercury Contamination in Virginia Waters: History, Issues, and Options

Introduction

Citizens, from scientists involved in research to the most infrequent fishermen, are looking for a silver lining in a dark cloud of mercury pollution that hangs as menacingly over Virginia's well-being as does Kepone. Knowledgeable persons generally agree that serious environmental problems in the form of mercury contamination exist in the North Fork Holston and South Fork Shenandoah rivers. Although officials do not necessarily agree on the extent of related health hazards or other complexities, responsible agencies and corporations are attempting to find solutions—if indeed, there are definitive answers to such issues as determining the responsibility for paying the cost of removing mercury from the waters, and preventing such pollution in the future.



Considering the magnitude of implications and potential perils, the general public needs to be as concerned as the professionals, and citizens need to become involved in imminent public hearings. Because of the importance of the controversy, this special report includes an article, reprinted in its entirety, from *Science*. The article provides a general framework and overview of the problems encountered in the pollution of Virginia's Holston and Shenandoah rivers.

Background

The world for centuries has had some knowledge of human maladies caused by mercury contamination. In the last three decades, numerous national and international incidents have significantly broadened the scope of concern. Mercury contamination was discovered in 1970 in the North Fork of the Holston River in southwestern Virginia, and was pinpointed in the South Fork Shenandoah River in 1977. "That the South River and North Fork Holston River are seriously contaminated with mercury, as a result of inadequate environmental safeguards by two industrial corporations prior to 1950 and 1970 respectively, is undeniable fact," writes Virginia's State Water Control Board (SWCB).[1] "No one has yet seriously accused the two corporations of deliberately and intentionally polluting the streams, nor of violating the environmental laws of the period in which the original pollution occurred during active operation of the plants. The corporations were obviously short-sighted, but the environmental laws of that period were far less stringent than those of today," the SWCB statement adds.

Although substantial progress to check the contamination has been made at both plant sites with continued cooperation of both companies, some leakage still continues into each river system. In July 1978, the SWCB tentatively adopted a "Proposed Mercury Standard and Policy for Freshwater in Virginia,"[2] designed to prevent mercury contamination of plant and animal life in the state's rivers, streams, and lakes, and to keep mercury pollution below levels that would affect tourism and other recreational uses of Virginia's water resources, as well as water supply, and commercial and sport fisheries. Taking fish for eating has been banned in each of the two rivers since the discovery of the respective problems. In recent actions, federal standards have been relaxed somewhat, while state norms have been stiffened.

The following article by Luther J. Carter, which appeared in the December 9, 1977, issue of *Science,* outlines Virginia's mercury contamination issues. Comments marked by asterisks were contained in the original article; footnotes 3, 4, and 5 are additions by the Virginia Water Resources Research Center.

"Chemical Plants Leave Unexpected Legacy for Two Virginia Rivers"
by Luther J. Carter†

The tourist passing through Virginia enjoys what for the most part is still a fine scene—the soft outlines of distant mountains, the sweep of lush valleys, and splendid pastoral vistas and riverscapes are all there to please the eye. Indeed, the official slogan, "Virginia is for lovers" is credible enough, for, besides the state's natural blessings, relatively little of it has been touched by the kind of industrial development that grossly pollutes or defaces. This being so, it is surprising and disconcerting to learn that three Virginia rivers are now so badly contaminated by toxic substances that well over 300 stream miles have been closed to fishing, or at least to the taking of fish for eating.

One of these rivers is of course the James, on which most commercial fishing is now prohibited from Richmond to the Chesapeake Bay because of contamination by Kepone.[3] But equally remarkable, though little attention has been given to it outside Virginia, is the contamination of much of the Shenandoah River and the North Fork of the Holston River by mercury.

In fact, this latter problem seems of special significance, both with respect to its persistence—which is extraordinary—and to the questions of regulatory philosophy and practice to which it gives rise.

Not all of the Shenandoah River is contaminated, only the South Fork, which many regard as the best of it. Indeed, if it had been the conscious intent of some malevolent force to do mischief to an exceptional natural treasure, the South Fork of the Shenandoah could have served well as the object of such perverse designs.

Flowing over a bed of limestone and frequent ledges, the South Fork runs northward in a series of great loops between the Blue Ridge Mountains on the east and the Massanutten Mountain on the west. For the canoeist or the float fisherman (the South Fork is famed for its smallmouth bass fishing), the scene is ever-changing but is always good and sometimes spectacular, especially when the winding river turns toward the steeply rising slopes of the Massanutten. Along with the rest of the Shenandoah, the South Fork has long been a prime candidate for consideration as part of the national system of wild and scenic rivers, and was so listed in President Carter's environmental message of last May [1977].

Although the Shenandoah was known to have some water quality problems, especially overfertilization from the runoff from farmland and other sources, it was not until this spring [1977] that state officials got word that part of the river might be heavily polluted with mercury. On 14 April a delegation from E. I. duPont de Nemours and Company, which has been manufacturing synthetic fibers at Waynesboro, Virginia, since 1929, called on Governor Mills Godwin and Virginia health and pollution control officials and brought the bad news.

Visible if minute globules of mercury had been discovered the previous September in the course of repairing a leaking water pipe beneath the Waynesboro facility's "old chemical building," where mercuric sulfate was used as a catalyst in the manufacture of acetate fiber between 1929 and 1950. Subsequently, analysis of sediment samples taken downstream from the plant in the South River showed that the sediment was heavily contaminated with mercury.

The readings for several samples exceeded 240 parts per million (ppm), compared to readings of less

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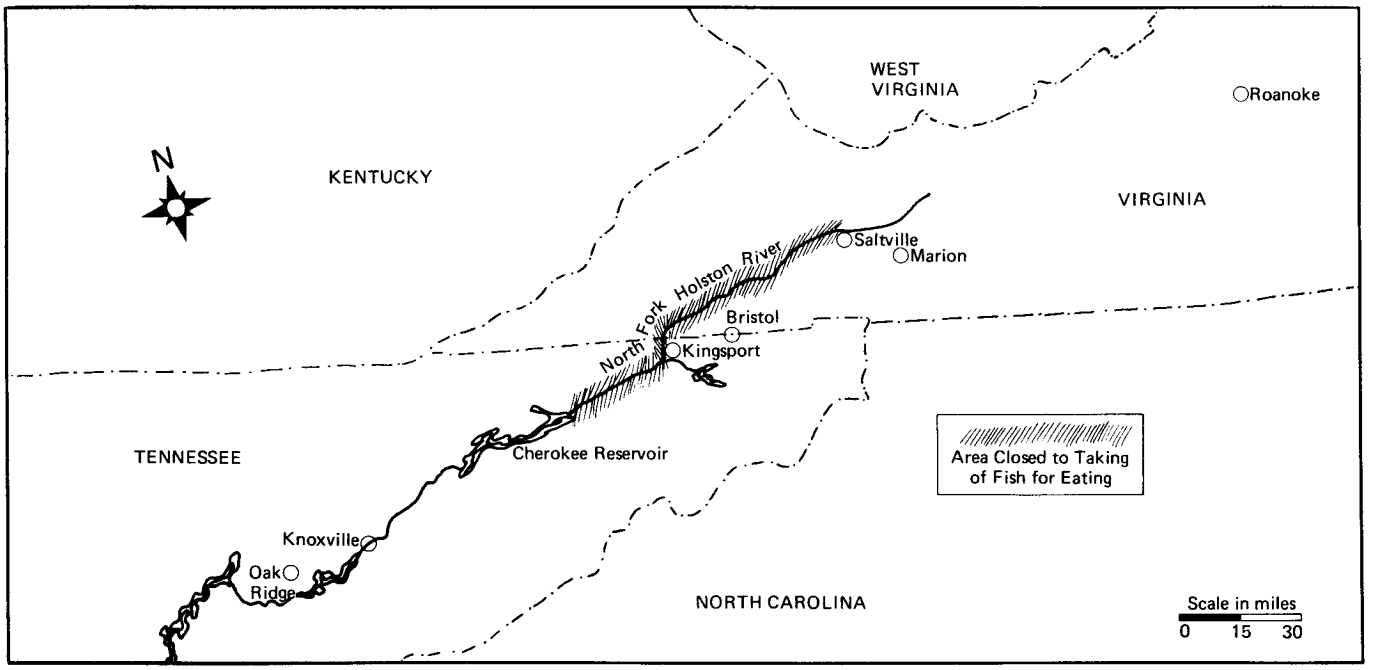

than 1 ppm for sediments tested upstream from the plant.[4] Worse still, the one fish that Dupont had had analyzed for mercury contained 0.86 ppm, or substantially above the Food and Drug Administration (FDA) "action level" of 0.5 ppm which cannot be exceeded in fish that are to be marketed. Although of no legal force in relation to freshwater game fish, which would not be sold commercially in any event, the FDA action level represented a standard by which Virginia health authorities would surely judge whether the fish were too contaminated to be eaten.

The disclosures made by DuPont to state officials were reported skimpily and almost routinely in the Virginia press, but their significance was soon to become more evident. On 6 June [1977] Governor Godwin announced, on the basis of sediment and fish samples collected and analyzed by the State Water Control Board (SWCB), that the South River below Waynesboro and the entire South Fork were closed to the taking of fish for eating. The mercury content in bass caught as much as 77 miles downstream from the DuPont plant had been found to be more than twice as high as the FDA standard.*

The extraordinary thing about this contamination problem is that it has been 27 years since mercury has been used in any manufacturing processes at Waynesboro, for in 1950 DuPont abandoned the particular acetate production process in which mercuric sulfate served as a catalyst. Moreover, from its sampling of soil and groundwater on the plant site, DuPont is now convinced that, although a few pockets of contaminated soil have been found, no mercury has escaped from the site into the river for many years. (The SWCB's director of enforcement, David S. Bailey, is "guardedly optimistic" that this will prove to be the case.)

As best anyone could tell, most if not all of the contamination of the river had taken place during the 1930's and 1940's as the result of spills of metallic mercury that occurred at the old chemical building. One likely possibility is that some of the spilled mercury was flushed into the river through storm drains. Normally, all mercury was recycled and the volume kept in active inventory, in 75-pound flasks, was never large. Edward T. Ruehl, the Waynesboro plant's manager for health, safety, and environmental affairs, believes that, all told, probably not much more mercury escaped to the river than could be put in a "Volkswagen gas tank."

*Actual or potential supplies of drinking water, for which Virginia has adopted a safety standard of 2 parts per billion (ppb), are not threatened. No mercury has been found in samples of either raw or filtered water taken at the town of Shenandoah, 50 miles downstream from the DuPont plant and the only community in the area that gets its water from the river (the limit of the Virginia State Department of Health's detection capability is 0.5 ppb). The SWCB failed to discover the Shenandoah's contamination during the nationwide mercury scare of the early 1970's only because it confined its investigation of this river to the taking and analysis of water samples.

Thus it seems that a relatively small quantity of mercury which got into the river between 1929 and 1950 has kept the river contaminated for a period of maybe 40 years or longer and may continue to contaminate it for decades to come. Major floods, such as the one that followed Tropical Storm Agnes in 1972, have repeatedly scoured the river bottom but, while some of the mercury in bottom sediments undoubtedly has been moved about, it has not been swept away.

Because of its great weight (it is 13½ times as heavy as water) and its liquid form, metallic mercury seems to find its way into sheltered nooks and crevices—of which the South River, with its irregular limestone bottom, has plenty—and is not easily dislodged. In fact, high concentrations of mercury are still found in sediment samples taken just below the DuPont plant from the natural trap formed by the remnants of a small dam.

Fifteen miles or so downstream from Waynesboro the mercury concentrations in sediments seem to fall off sharply. But they remain at above natural background levels all the way down the South Fork to Front Royal, 130 miles from the DuPont plant, and for at least 30 miles down the Shenandoah's main stem.

Over a period of years and decades, metallic mercury in bottom sediments can be converted at varying rates to ionic inorganic mercury and to organic or methyl mercury, both of which can be easily transported downstream by river currents. Although relatively insoluble in water, some metallic mercury does dissolve, and part of this dissolved mercury becomes attached to suspended soil particles and part remains in solution.

But more important to the uptake of mercury by aquatic life is the fact that microorganisms abundant in the sediments can convert virtually any form of inorganic mercury to methyl mercury. In this form mercury is taken up rapidly by aquatic plants and animals and—of particular significance to its potential for attaining high concentrations (especially in older and larger fish)—it is excreted slowly, having a "biological half-life" of months or even years.

It is in its methylated form that mercury is particularly toxic to humans. If ingested in sufficient amount through a heavy diet of fish (as has happened in Japan), methyl mercury can cause Minimata disease, a severe disorder of the nervous system that can be fatal. By good fortune, no cases of Minimata disease are known to have occurred in Virginia, although epidemiological data are too limited to rule out all possibility of instances of mercury poisoning.

The mercury problem in southwest Virginia on the North Fork of the Holston River, which is far removed from the Shenandoah watershed and is actually part of the Tennessee River system, is in some important respects more frustrating to SWCB officials than the one on the Shenandoah.

The essential difference between the two situations is that, whereas there is as yet no evidence that the Shenandoah is being further contaminated by more mercury from DuPont's Waynesboro facility, the Holston is constantly receiving more mercury from the site of the now closed and dismantled chlorine plant which the Olin Corporation of Stamford, Connecticut, operated at the town of Saltville until the spring of 1972. Moreover, the situation at Saltville is such that the inflow of mercury into the river may never be stopped entirely, whatever the plan of remedial action ultimately agreed to by Olin and the SWCB.

Coincidentally, it was in 1950, the year DuPont stopped using mercury at Waynesboro, that Olin (or rather one of its corporate progenitors, the Mathieson Chemical Company) began using mercury at Saltville, which is noted for its huge underlying salt deposit. For the next 22 years, until the plant was finally shut down (partly because of the pollution control requirements that were to be imposed), mercury served as an electrode in the electrolytic process used to break down sodium chloride to produce chlorine and caustic soda.

In contrast to the situation at the DuPont plant, where mercury was needed in relatively small amounts, the Olin plant used it in huge volume, with the electrolytic cells containing more than 1 million pounds of the metal. As was true of chlorine plants elsewhere, this one at Saltville lost mercury in prodigious amounts, although the aim was supposedly to recycle as much of it as possible.** Until 1970 and the big nationwide scare over mercury that led to restrictions on the catching or sale of mercury-contaminated fish in nearly a score of

**According to the 1976 report of the National Commission of Supplies and Shortages, during the period 1964 to 1973 chlorine plants in the United States required 463 metric tons of mercury annually to make up for losses. This figure was stated as a yearly average for the period, however, and the actual losses after 1970, when production processes were tightened up drastically, were probably much less.

states, up to 100 pounds of mercury was lost every day of plant operation. Some of it was lost as vapor, but much of it was lost as liquid mercury spilled on cell room floors or carried away in various waste streams, at least one of which went directly into the river.

Neither Olin nor state health and pollution control officials had been aware of the hazards to human health resulting from loss of mercury to the river. For it was not until the late 1960's that the methylation phenomenon by which mercury is made more readily available to aquatic life was discovered by Swedish researchers. Once the danger was realized, the changes brought about at the Saltville plant as well as at other chlorine plants around the country were remarkable. Losses were reduced to as little as a quarter of a pound of mercury a day.

Nevertheless, the cumulative effect of the reckless practices of the past (the health hazards of mercury vapor at least had long been known) had led to what may be an almost hopelessly bad problem of environmental contamination. How much mercury has gone into the river is beyond calculation; all one knows is that the mercury concentrations in both sediments and fish are high today and are likely to remain high for decades, if not generations, to come.

Three-fourths of the fish samples taken in July 1976 at six stations along nearly 70 miles of river showed concentrations at least twice as high as the FDA action level. There is in fact evidence that the contamination extends far down the main stem of the Holston to the Tennessee Valley Authority's big Cherokee Reservoir, more than 100 river miles from Saltville. Eight fish collected this past May [1977] from the reservoir's far upper reaches all showed concentrations exceeding the FDA limit. While the sample was too small to justify a ban on the eating of fish from the reservoir—in the case of the North Fork such a ban was imposed by Virginia and Tennessee health authorities in 1970—it was an ominous sign.

Mercury continues to enter the Holston both from the site of the old chlorine plant and from the two big "muck ponds" which were used for disposal of the primary waste stream from the Olin complex. The grounds on which the "cell building" once stood contains an astonishing amount of mercury: according to an Olin consultant, there are some 220,000 pounds of it.

Although the mercury is believed to be present in the soil profile to depths of as much as 30 feet, it is also found near the surface. Sizable globules of it can be seen along the eroded bank of the river, and during this reporter's recent visit there, a small clod taken from the bank virtually at random contained a globule larger than a dime. Anytime the Holston is in flood, significant amounts of the metal are swept into the stream.

Serious as it is, the problem at the old plant site can perhaps be corrected either by excavating the contaminated soil and extracting the mercury, or, as Olin is now proposing, by sealing off the site from the river with a shield of impervious clay and riprapping. (In 1973, Olin tried to clean up the site by removing the top foot or so of soil, but, as is now evident to all, this was pathetically inadequate.) As for the muck ponds, it has become increasingly apparent that this problem can never be fully overcome; anything short of gargantuan engineering remedies, undertaken at costs that might run into the hundreds of millions, may bring nothing better than a modest, perhaps trifling, amelioration.

The ponds, which cover about 120 acres and extend along the river for more than a mile, contain an accumulation of salts and other wastes that is up to 80 feet thick. Although not much water stands in these basins now, enough water enters them from direct rainfall and from runoff from the adjacent mountainside to make for a problem of mercury-contaminated chloride solutions seeping into the river. The discharge of mercury to the river from this source is estimated to average about 100 grams a day year in and year out. Given the Holston's present grossly contaminated condition, *any* additional inflow of mercury would be considered intolerable were there any practical means of preventing it. So far, Olin and its consultants have come up with nothing better than a plan to dig a ditch along the mountainside to intercept the surface runoff; but this would at best reduce the seepage into the river by only half, and, if the SWCB staff is correct in its assessment, the reduction would be much less than that.

However severe and pressing the problems at Saltville, the SWCB has generally shown little sense of urgency in dealing with them. Even the matter of finding a prophylactic remedy for the problem at the chloride plant site continues to drag on. "We haven't been balls of fire on this thing," acknowledges Richard Hill, an aide to one of the top SWCB officials. In part, the situation at Saltville seems to reflect the fact that, absent an imminent health threat or economic loss (both present in the Kepone affair), something such as a ban on eating fish from

a mercury-contaminated river does not appear to bring a public outcry in Virginia. Scarcely anyone showed up either at the public hearing which the State Department of Health held in 1973 on the Holston ban or at the one it conducted on the Shenandoah situation. In light of the sharp decline in fishing on the famed Shenandoah, the poor turnout for the hearing on the ban there—no local officials were present and only two citizens—was astonishing.

Actually, from a regulatory standpoint, the mercury pollution problem poses several hard questions that deserve the public's thoughtful attention. Especially is this true in the Holston River case where there is clearly an opportunity to go beyond measuring the extent of the contamination and to reduce the sources of further pollution.

For instance, how far should the state go in holding Olin accountable for the problem at Saltville? After shutting down the plant, Olin gave most of its property there to the town and state, and at present retains title chiefly to some mineral rights and to the muck ponds (which it wanted to give away but could not). Although town council members praise Olin for treating Saltville fairly and generously, the company clearly does not feel that it has an open-ended obligation to see that the mess which it created on the Holston is cleaned up.

Although willing enough to assist in trying to seal off the site of the chlorine plant from the river, Olin wants the SWCB and the town to agree that once a plan of remedial action has been approved and carried out, its obligation with respect to the problem will end. Yet there may not be complete assurance that the plan will succeed. Certainly the efficacy of any remedies tried at the muck ponds will be in doubt. Bailey, the SWCB enforcement chief, indicates that, in his view, the burden of ultimate responsibility is Olin's forever. "I don't think it would be in the state's best interest to enter into a final, blanket agreement," he says.

Another question is, should the state expect some compensation from Olin and DuPont for the contamination of the two rivers? In the Kepone episode, the Allied Chemical Corporation, found to have committed gross violations of law, has been ordered to pay the state and federal governments $18.5 million in penalties, including $5 million which will go for research on Kepone in the environment; yet the company remains open to millions in damage claims and to demands by the state in the future for a massive and costly cleanup of the James River if this should be feasible.[5]

As A.H. Paessler, the SWCB's deputy executive secretary, has observed, the mercury contamination of the Shenandoah and the Holston "resulted from no flouting of state or federal law by DuPont and Olin, and neither has been so accused." Nevertheless, as Paessler also acknowledges, the contamination is a fact and those companies are the cause of it. To measure the damage in precise dollar terms would be impossible, but it is clear that the sports fisheries that existed on the Shenandoah and the Holston (the latter was a resource of at least local significance) were of considerable value and that they have been hurt severely. Some informal discussion of the matter of compensation has gone on within the SWCB staff, but there is no sign that it will be pursued.

Closely related to the compensation issue is the question of whether something might be done to rehabilitate the river—or at least shorten the period of contamination. One idea sometimes mentioned is to try to identify and remove some of the more heavily contaminated sediments. The SWCB staff has searched the relevant literature for possibilities, but thus far has found nothing that looks promising.

The agency is now soliciting help in this matter from the Environmental Protection Agency, which so far has left the mercury problem to the state, and from the U.S. Army Corps of Engineers, the Tennessee Valley Authority, and the Oak Ridge National Laboratory. But should any plan for partial rehabilitation of the Shenandoah or Holston be proposed, the question will then surely arise as to who shall pay for carrying it out—the state, the federal government, the company, or all three?

Still another regulatory question raised by the mercury problem has to do with the FDA action level. R.V. Davis, the SWCB's executive secretary, has suggested that the action level perhaps should be raised. Although this suggestion might at first glance be likened to the one somebody once made with respect to Vietnam—declare victory and withdraw—it finds some support in scientific circles.

In Sweden, where extensive research has been done on mercury problems, the action level is twice as high as the one in this country, and some American scientists (such as Peter Krenkel of the Tennessee Valley Authority) believe the FDA limit is needlessly stringent. James B. Kenley, Virginia's commissioner of health, has rejected Davis' suggestion, however. He observes that the action level for mercury is based on "a far larger amount of information and a far lower safety factor" than the action level for Kepone.

In truth, the mercury contamination of the Shenandoah and the Holston appears to have been one of those bad turns of fate about which not much can be done—or at least not much of certain efficacy. But this is not to say that the best response is simply to adjust to the problem and leave the solution to the ages.

Discussion

The SWCB regards Luther's treatment of Virginia's mercury pollution as "accurate in respect to the environmental and historical facts it presents," although alternative judgments might have been made. The questions... raised relative to regulatory philosophy and performance are certainly pertinent...."[6] In the course of searching for feasible solutions to the specific problems resulting from the contamination, the SWCB has been involved in extensive negotiations. Currently, the agency is part of a special interstate mercury task force dealing with contamination in the Holston River and the Tennessee Valley Authority's Cherokee Reservoir into which the Holston empties.

Virginia at present is not represented in a second task force aimed at coordinating research and restoration activities in the Cherokee Reservoir, although the SWCB staff continues to monitor the Saltville situation and to follow with interest the cleanup and control measures taking place in Virginia. The SWCB staff is surveying 20 miles of the South River in preparation for the possibility of dredging, though the advisability of such a step currently is quite speculative. The Virginia State Department of Health, which tightened health regulations in the wake of the state's Kepone incident and has proposed revised standards to provide safeguards relative to the existing mercury situation, takes exception to several technical points in Luther's presentation (see footnotes 3, 4, and 5).

Mercury contamination in two of Virginia's best smallmouth bass fishing waters undeniably constitutes a major environmental problem and threatens public health and enjoyment. Although dredging is being explored as a possible remedy, no quick or easy solutions are likely. An increased awareness of the facts in this issue and continued open forums exploring acceptable actions are essential to the long-term benefit of concerned citizens of the state.

Footnotes

1. Correspondence from R. V. Davis, Executive Secretary, State Water Control Board, to Virginia Water Resources Research Center, June 15, 1978.
2. State Water Control Board, Division of Ecological Studies, Bureau of Surveillance and Field Studies, "Proposed Mercury and Policy for Freshwater in Virginia," June 1978.
3. Oscar H. Adams, Deputy Assistant Commissioner for Environment, State Department of Health, points out that "since the initial closure orders were written on the James River, the Kepone action level for finfish was raised by the Food and Drug Administration, thus permitting the commercial harvesting of catfish, shad, and herring. As these are the predominant commercially important species, most commercial fishing is now permitted. Recreational fishing is limited more severely."
4. Adams (see note 3) suggests that the 240-ppm figure "is misleading since these samples exceeded this value and the majority of these samples were in the 0.1-0.3 range. Actually three samples taken back of a small dam at Dooms showed higher values (285, 250, and 245 ppm) than 240 ppm."
5. Adams (see note 3) indicates that the statement that Allied was found to have committed gross violations of law and was ordered to pay the state and federal governments $18.5 million is misleading and inaccurate. "The federal judge fined Allied $13.2 million setting aside $8 million in favor of the Virginia Environmental Endowment. The $5.25 million settlement reached between Virginia and Allied was to compensate Virginia and Hopewell for Kepone-related costs and those additional studies necessary for identifying cleanup actions for the river and developing a disposal means."
6. State Water Control Board (see note 1).

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