CHEMICAL QUALITY OF SURFACE WATER

By
James W. Crooks

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Chemical quality of water is a measure of the chemical suitability of water for intended uses. It is determined by comparing chemical characteristics of water to established standards and criteria or suggested chemical tolerances of water for specific uses. All surface water in the Patuxent River basin, except saline water in the lower estuary, is acceptable for public supply and selected industrial use after it has received minor treatment; the water is suitable for irrigation without treatment.

General Evaluation.—Three zones have been delineated within the Patuxent basin on the basis of differences in chemical characteristics of surface water. Zone A contains water with slightly lower concentration of dissolved solids than water in zone B, and the estuary contains a mixture of waters from zones A and B and saline water from Chesapeake Bay. The probable maximum concentration of dissolved solids in zone A is about 100 ppm (parts per million); in zone B, about 250 ppm. The probable maximum concentration of dissolved solids in the estuary may be as low as 250 ppm in the upper reaches or as much as 20,000 ppm near the mouth.

The delineation of the areas and the evaluation of the water quality is based on samples collected at 35 stream sites during low flow, at 12 of the same sites during high flow, and on samples collected at approximately 2-week intervals for nearly a year at three stream sites. Information on chemical character of water in the lower estuary was provided by R. L. Cory, U. S. Geological Survey (oral communication 1965).

Concentrations of dissolved solids generally were higher on samples collected during low flow, but the differences were not great. Concentrations of dissolved solids were slightly different from one location to another, and concentrations of specific ions such as chloride and nitrate were higher than the probable normal concentration at a few sites because of waste effluents in the streams.

Samples collected at 2-week intervals from the Patuxent River at Laurel and at Hardesty, and the Little Patuxent at Fort Meade varied in mineral content as a result of variations in flow and variations in waste effluents that enter the system upstream. Generally the concentrations of dissolved solids are comparable to those of the zones in which the sites are located. Dissolved solids at Laurel ranged from 41 to 60 ppm; at Fort Meade from 60 to 136 ppm; and at Hardesty from 49 to 99 ppm. The higher values for the site at Fort Meade undoubtedly result from wastes entering the stream above the sampling site. Water in the Patuxent River at Hardesty is comprised mostly of low mineral content water of zone A and a smaller amount of the slightly higher mineral content water of zone B.

Quality for Public Supplies.—[As shown in lower diagram] Surface water in the Patuxent River basin generally is well within the acceptable limits proposed by the U. S. Public Health Service drinking water standards (1962). However, some water contains excessive amounts of iron and manganese which must be reduced before the water can be considered acceptable. Concentrations of iron ranged from 0.07 to 9.4 ppm and concentrations of manganese ranged from 0.00 to 3.0 ppm in samples collected at Laurel. These values are well above the recommended limits of 0.30 ppm for iron and 0.05 ppm for manganese. The concentrations of iron and manganese were lower at Hardesty and Fort Meade but at all sites the iron limit was exceeded more than two-thirds of the time and the manganese limit was exceeded more than a fourth of the time.

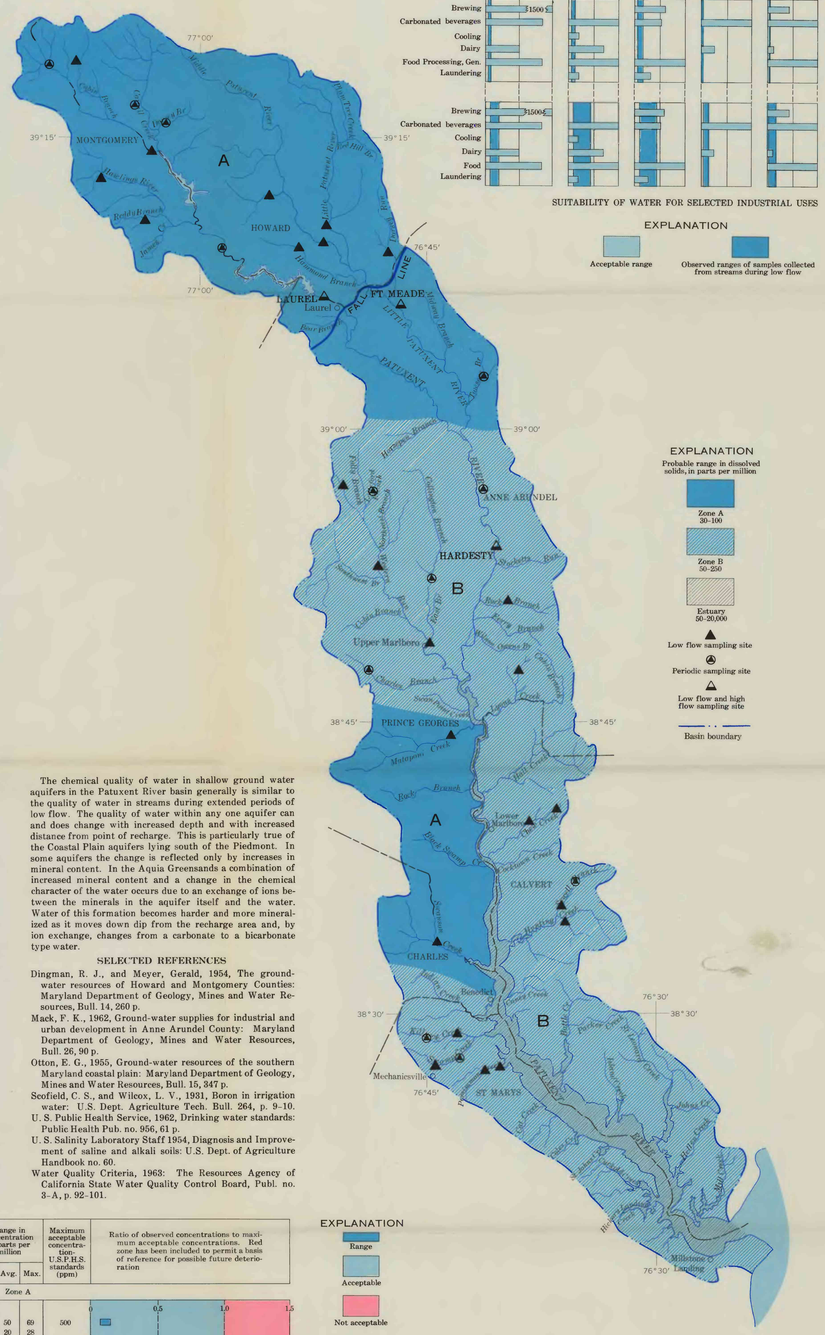
Water in the upper reaches of the estuary probably is suitable for public supplies but becomes intolerably saline progressively downstream.

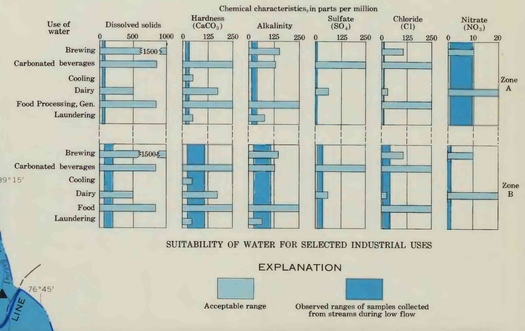
Quality for Industry.—Surface water in the Patuxent River basin, excepting saline water in the estuary, will meet most of the water quality criteria (Water Quality Criteria, 1963)for the industries[shown in upper diagram]Some industries, such as those producing beer and carbonated beverages and those using water for cooling, may require a higher concentration of hardness, dissolved solids or specific ions than the minimum values indicated on the chart. Such minimum values are not well defined for general use and usually are set by the individual water user.

Saline water in the estuary can be used for cooling or other purposes that have high tolerances of salinity.

Quality for Irrigation.—Although surface water is not commonly used for irrigation of crops in the Patuxent basin, recurrent droughts, increasing competition for water, and increased demand for production of crops, may necessitate future agricultural use of these streams. On the basis of the SAR (sodium-absorption ratio), and concentrations of boron and residual sodium carbonate as indices, all surface water in the basin, except saline water in the estuary, is suitable for irrigation. All SAR values were less than 2.0, indicating a very low salinity and sodium hazard. Only seven sites of those sampled had residual sodium carbonate. All were less than 0.15 epm (equivalents per million), considerably below the limit of 1.25 epm suggested for sensitive crops. Only four of 19 samples collected at 12 sites contained boron; the maximum concentration of 0.12 ppm, observed at Hardesty, is well below the minimum of 0.33 ppm suggested as a limit for sensitive crops.

Quality for Recreation.—There are no set standards by which water may be evaluated for recreational uses. Generally accepted guidelines, however, require that the water should be clean and be free of toxic materials and obstructions that are hazardous to fish, animals, and man.The continued popularity of streams in the Patuxent basin for boating, fishing, crabbing, and other water sports suggests that the water is acceptable for recreation in many areas. Locally (see Pollution Index), the addition of wastes to streams has detracted from the recreational potential of the water.





SUITABILITY OF WATER FOR SELECTED INDUSTRIAL USES

The chemical quality of water in shallow ground water aquifers in the Patuxent River basin generally is similar to the quality of water in streams during extended periods of low flow. The quality of water within any one aquifer can and does change with increased depth and with increased distance from point of recharge. This is particularly true of the Coastal Plain aquifers lying south of the Piedmont. In some aquifers the change is reflected only by increases in mineral content. In the Aquia Greensands a combination of increased mineral content and a change in the chemical character of the water occurs due to an exchange of ions between the minerals in the aquifer itself and the water. Water of this formation becomes harder and more mineralized as it moves down dip from the recharge area and, by ion exchange, changes from a carbonate to a bicarbonate type water.

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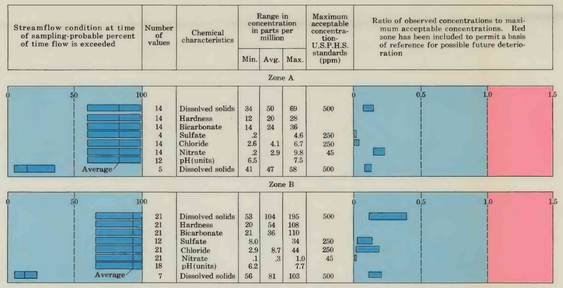

SUITABILITY OF WATER FOR PUBLIC SUPPLY

EROSION AND SEDIMENTATION

By
James W. Crooks and Deric O'Bryan

EROSION AND SEDIMENTATION

Thousands of tons of sediment are removed from land surfaces in the Patuxent River basin each year by erosion. The soils are eroded by rainfall and overland runoff, carried by streamflow, and deposited as sediment in reservoirs and the estuary. More sediment per unit area is removed from the Piedmont than from the Coastal Plain. The greatest amounts of sediment are derived from areas cleared for cultivation, or for highway and urban development regardless of topography or local geology.

The higher sediment yield of the Piedmont is a result of steeper topography and less permeable soils than in the Coastal Plain. Studies in 1964 of the Patuxent River at Unity and the Little Patuxent River near Guilford, both Piedmont streams, show sediment yields of 130 and 175 $t/mi^2/yr$ (tons per square mile per year) for the basins of the respective rivers. By comparison, Anderson and George (1966) estimate yields of 75 to 500 $t/mi^2/yr$ for New Jersey streams in the Piedmont. A comparison of sediment yields of streams in the Patuxent basin to other adjacent streams in Maryland (Wark and Keller, 1963) is shown.

Sediment yields from the lower Patuxent basin in the Coastal Plain are estimated to range from 30 to 100 $t/mi^2/yr$. Mattawoman Creek, draining a Coastal Plain area into the Potomac River just west of Upper Marlboro, is reported by Wark and Keller (1963) to have a yield of 30 $t/mi^2/yr$. An estimated yield of 10 to 100 $t/mi^2/yr$ of sediment is given by Anderson and George (1966) for New Jersey areas in the Coastal Plain. A comparison of sedimentation rates of Piedmont and Coastal Plain streams shows how sediment yields differ in the two provinces with comparable stream discharge values.

Even greater differences in sediment yield occur because of differences in vegetation cover and land use. Yields may be as low as 20 $t/mi^2/yr$ from heavily forested areas in the Piedmont and even less in the Coastal Plain. Yields for streams at three sites in the Patuxent basin are compared to yields for streams in the Potomac basin on the basis of percent forest cover.

Erosion from Piedmont lands is greatly influenced by the proportion of land under cultivation and of land disturbed by suburban and other types of construction. Ray Vice, U. S. Geological Survey, reports that in a study of sediment yields in the basin of Scott Run near McLean, Virginia, average annual sediment yields per acre for land disturbed by construction is in the order of 15 times greater than for land under cultivation and many hundred times greater than for land under forest and grass (oral communication, 1966). Harold P. Guy and George E. Ferguson (1962), in a study of Lake Barcroft, Virginia, near Washington, D. C., report that yields of 200 to 300 $t/mi^2/yr$ are increased to yields of 25,000 to 50,000 tons during periods of construction. Comparable information on the effects of cultivation and urbanization is not available for Coastal Plain areas of Maryland but accelerated rates probably would be considerably less than those of Piedmont areas because of flatter topography and more permeable soils.

Estimates of sediment yield from the entire Patuxent basin including both Piedmont and Coastal Plain areas are provided below to show how sediment yields are affected by variations in land use.

Land use	Tons per square mile per year
Forested land	20 - 100
Pastures and fields	200 - 1,000
Urban and highway development	10,000 - 100,000
Urban and stabilized suburban developed land	50 - 100

Large but undetermined quantities of sediment from the upper portion of the basin deposited in the estuary have filled channels formerly used for shipping, and other deposits have reduced the capacity of Triadelphia and other reservoirs. Historically, shipping extended several miles above Hardesty; now, only shallow-draft vessels may travel in the Patuxent above Benedict. Studies of Triadelphia reservoir by the U.S. Department of Agriculture (unpublished data, 1965) show that the reservoir has lost nearly 5 percent of its original capacity or over 1,000 acre-feet during the period 1942 to 1964. A comparison of sediment deposition in this and other reservoirs in Maryland is shown. Data are not available on the historical land use for the drainage area of the Triadelphia reservoir but it is presumed that the accelerated rate of sedimentation of the reservoir, particularly during the 1958-1964 period is a result of increased housing and highway development. Similarly, the period of large sediment accumulation reported for Greenbelt reservoir (1936-38) coincided with the construction of the Greenbelt community.

Because the above effects of sedimentation have developed over a relatively long period of time, they have not caused alarm. As the basin develops more rapidly, especially in the reach between Washington and Baltimore—the problem will become more evident. It can be estimated that complete development and urbanization of the Piedmont section for example, will generate 100 to 200 million cubic feet of sediment to be transported to the reservoirs and to the estuary reducing considerably the recreational and commercial value of those water bodies.

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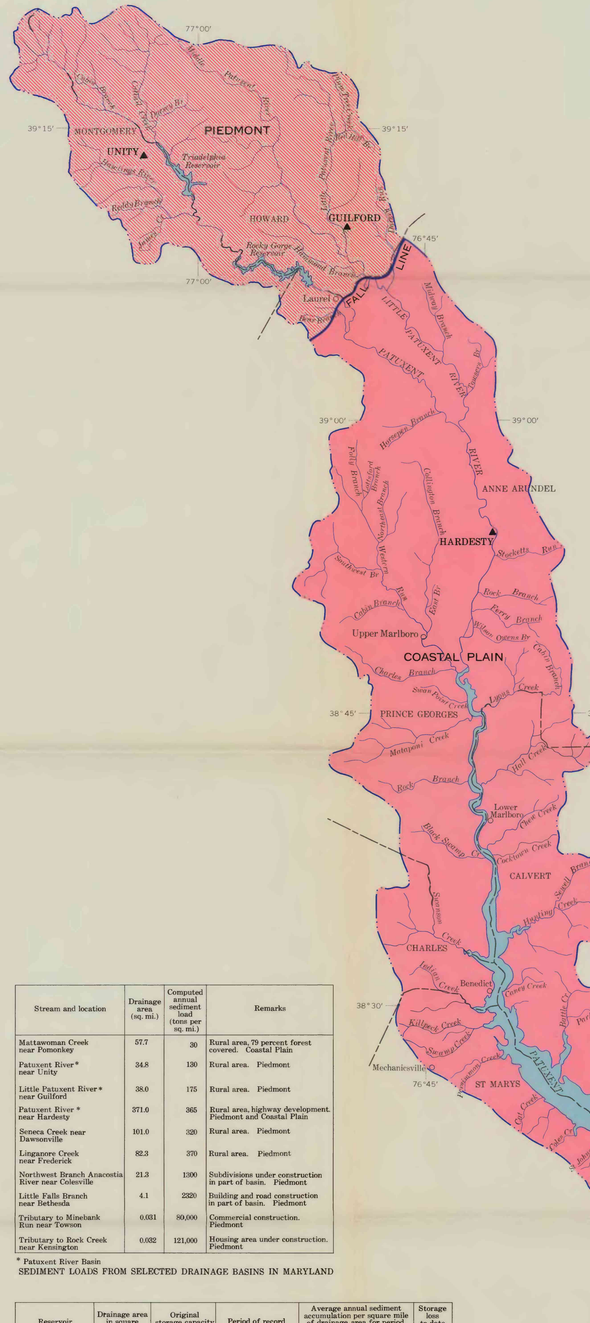
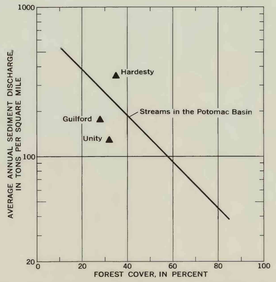
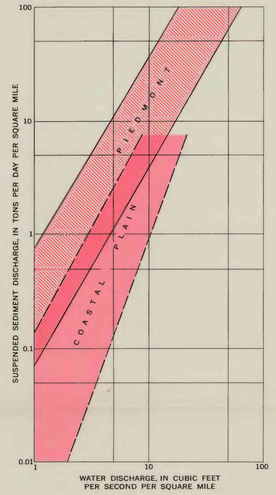




COMPARISON OF RELATIONSHIPS BETWEEN SEDIMENT DISCHARGE AND LAND USE OF STREAMS IN THE PATUXENT BASIN TO STREAMS IN THE POTOMAC BASIN



COMPARISON OF RANGES OF SEDIMENT DISCHARGE RATES FOR STREAMS IN THE PIEDMONT AND COASTAL PLAIN (NEW JERSEY TO VIRGINIA)

Stream and location	Drainage area (sq. mi.)	Computed annual sediment load (tons per sq. mi.)	Remarks
Mattawoman Creek near Pomonkey	57.7	30	Rural area, 79 percent forest covered. Coastal Plain
Patuxent River* near Unity	34.8	130	Rural area. Piedmont
Little Patuxent River* near Guilford	38.0	175	Rural area. Piedmont
Patuxent River * near Hardesty	371.0	365	Rural area, highway development. Piedmont and Coastal Plain
Seneca Creek near Dawsonville	101.0	320	Rural area. Piedmont
Linganore Creek near Frederick	82.3	370	Rural area. Piedmont
Northwest Branch Anacostia River near Colesville	21.3	1300	Subdivisions under construction in part of basin. Piedmont
Little Falls Branch near Bethesda	4.1	2320	Building and road construction in part of basin. Piedmont
Tributary to Minebank Run near Towson	0.031	80,000	Commercial construction. Piedmont
Tributary to Rock Creek near Kensington	0.032	121,000	Housing area under construction. Piedmont

* Patuxent River Basin

SEDIMENT LOADS FROM SELECTED DRAINAGE BASINS IN MARYLAND

Reservoir	Drainage area in square miles	Original storage capacity (acre-feet)	Period of record	Average annual sediment accumulation per square mile of drainage area for period		Storage loss to date
				Tons	Acre-feet	(Percent)
Triadelphia (Brighton, Md.)	80.08	24,625	June 1942-Oct. 1950	218	0.20	0.66
			Oct. 1950-Sep. 1958	479	.71	2.91
			Sep. 1958-Aug. 1964	1650	1.24	4.77
Loch Raven (Towson, Md.)	219.4*	64,813	1914-Oct. 1943	808	.618	7.63
			Oct. 1943-June 1961	233	.187	8.69
Atkinson (Belair, Md.)	45.35	896	May 1942-May 1954	459	.351	21.29
Burnt Mills (Silver Spring, Md.)	26.97	181	May 1930-March 1938	533	.408	47.51
Greenbelt (Greenbelt, Md.)	.79	196	July 1936-Feb. 1938	10,337	7.91	5.10

* Net sediment contributing area was 299.4 sq. mi. until 1933 when Prettyboy was completed. This area was used in the 1943 calculations

COMPARISON OF SEDIMENT ACCUMULATION IN TRIADELPHIA RESERVOIR WITH SELECTED RESERVOIRS IN MARYLAND (DATA FROM U.S. DEPT. OF AGRICULTURE)

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1967—W66463

WATER RESOURCES OF THE PATUXENT RIVER BASIN, MARYLAND

By
James W. Crooks, Deric O'Bryan, and others

1967