SYMPOSIUM ON SELF-PURIFICATION OF SPOKANE RIVER

(Three Articles Appearing in This Symposium Were Read Before the Bacteriology-Public Health Section of Northwest Scientific Association, December 29, 1936)

The Sanitary Significance of the Spokane River

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A frontier people need have no concern about the water they drink, nor where they dispose of their waste. Water generally is pure until it is defiled by man. But as civilization advances the polluted streams become a problem. Fifty years ago this problem became acute in the East, twenty years ago in the Middle West and today it confronts us.

There are many questions which have arisen from this situation that scientific men have tried with varying degrees of success to answer. One of these questions is: How quickly will a given stream or body of water recover from a given pollution load? This question has been the cause of a number of investigations by the U. S. Public Health Service, and among the very interesting and instructive bulletins to be had are studies on the Ohio, Illinois and Mississippi rivers.

During these studies, it was found that of the many tests that were made, the two that gave the most accurate picture of the extent of pollution were *B. coli* and biochemical oxygen demand. Studies on a very much less extensive scale than this made by the U. S. Public Health Service have been made for the past fifteen years on the Spokane River by local authorities, a full report of the findings of which are entirely too voluminous for such a paper as this. so we will deal in this paper only with the general characteristics of the Spokane River and a brief analysis of the findings and conclusions that can be drawn from the B. O. D. (biological origin demand) studies.

THE RIVER.

The Spokane River has its source in Coeur d'Alene Lake, a body of water about 30 miles in length and fed from streams having their origin in the mountains of northern Idaho and western Montana, the St. Joe, St. Maries and Coeur d'Alene rivers being the principal tributaries. From the source of the Spokane River to its outlet in the Columbia it travels a distance measured along its course of about 105 miles, and has a fall of about 1050 feet. From the lake to the City of Spokane, a distance of 30 miles, it flows through the Spokane Valley, a broad, gravelly and intensely cultivated valley, the greater part of which is under irrigation.

Below the city, the river is swift and flows mostly between high steep banks unsuited for farming, not only because of their steepness, but because of the poor sandy and rocky nature of the soil. There are flowing into the river only two tributary streams of any consequence: Hangman Creek, outletting just below the business section of Spokane, and the Little Spokane, about 15 miles below the city.

Although the rivers feeding into the Coeur d'Alene Lake have at times a combined flow estimated at over 100,000 cfs, the equalizing effect of the lake and its restricted outlet has resulted in a maximum flow in the Spokane River of a little less than 50,000 cfs. The low-water flow is regulated by the control works of the Washington Water Power Company—Post Falls Dam, and seldom is allowed to get below 1500 cfs.

A study of annual flow tables shows that there is only 10 per cent of the time

when the flow is less than 1700 cfs. During the low water month, the amount of water entering the river through Hangman Creek and the Little Spokane is so small that their influence may be ignored.

THE POLLUTIONS.

In the drainage area tributary to Coeur d'Alene Lake there is a population of approximately 22,000, only a comparatively small percentage of which, however, lives in cities of sufficient size to be served by sewers.

The first direct source of pollution entering the Spokane River is from Coeur d'Alene, a city of about 8,000 population, whose sewers enter just below the outlet of the lake.

The next source of pollution of any consequence is at Millwood, where the Inland Empire Paper Mill discharges its sewage and mill waste into the Spokane River. When the mill is running at capacity and all of the sulphite liquor is being discharged into the river, this plant has an estimated population equivalent of 115,000. During the past few years, however, a large amount of this waste liquor has been used as a dust palliative on Spokane City streets, which has greatly reduced the pollution entering the river from this plant.

During the low-water season, if none of this sulphite is dumped into the stream, the population equivalent of the plant is from 30,000 to 40,000.

The last and principal source of pollution is the sewage from the City of Spokane. The Spokane River divides the city into two equal parts, so far as population is concerned, and there are 25 subtrunk sewers entering the river at various places, from Sharp Avenue on the East to Assembly Street on the West. In addition to this, there are numerous small industries along the river bank which discharge their waste into the stream.

The estimate made by Mr. Greeley, Consulting Engineer, of the pollution load of the river as it leaves the city, predicated on the number of sewer connections, vaults and cess pools cleaned, kill of animals at the slaughter houses and B. O. D. basis for industries is as follows:

Item	Upper Estimates	Lower Estimates
1. Human population connected to sewers	60,000	60,000
2. Population equivalent of minor industries	30,000	30,000
3. Unsewered population	7,000	7,000
4. Major industries in city limits	80,000	35,000
5. Upriver industrial and miscellaneous	110,000	40,000
	287,000	172,000

In order to determine the characteristics of the sewage being discharged into the river, a number of samples taken from the principal sewers were analyzed, the results of which showed an average suspended solids of 220 ppm, and a five day B. O. D. of 230 ppm. The measured flow from the 25 sewer outlets showed an average total flow of 21.71 cfs. On this basis we have a total of 26,000 pounds of suspended solids and 27,000 pounds of B. O. D. in 24 hours discharge into the river. During the same time that these sewer samples were taken, a number of analyses were made of the Spokane River, the average of which showed a B. O. D. of the river above the city of 1.47 and below the city of 2.17, or a difference in oxygen demand of .7 ppm. During this period the average flow in the river was 6,000 cfs. If then, we use this as a basis, we have total pounds of water per 24 hours times .7, or 22,680 pounds of five-day B. O. D., a closer check perhaps than the data at hand might warrant.

SELF PURIFICATION.

The rate at which a polluted stream will rehabilitate itself, depends upon the quantity of oxygen it will absorb in a given time, and this in turn depends upon the area of water surface exposed per unit of volume.

In turbulent streams, the rate of reaeration is high because new surfaces of

water are being constantly brought in contact with the atmosphere. Such streams, however, carry the pollution a greater distance down stream before a given amount of self-purification is effected. The extent of self-purification then, which is brought about in a given distance, depends somewhat on the time it takes the water to reach a given point. This being true, let us now consider the length of time required for the water from Spokane to reach the Columbia and also the characteristics of the stream which would favor self-purification. After a few miles of rapid flow below the city, the river enters the backwaters of Nine Mile Dam. After passing through this and over the dam, it enters immediately into the backwaters of the Long Lake Dam and again into the backwaters of Little Falls Dam. From there the river is a rapid turbulent stream for a distance of about 25 miles to its outlet into the Columbia.

The characteristics of the river below the city may be tabulated as follows:

Pool back of	Volume in million cubic feet	Displacement time in hours for river flow of 1700 cfs.	Surface area of pool in thousand square feet.
Nine Mile	227	37	30,000
Long Lake	10,000	1630	210,000
Little Falls	185	30	8,000

The displacement of the pool waters back of the dams is very probably not complete and there are volumes along the bottoms and shores, where the displacement is caused by wind or cross currents, rather than river flow. Thus the time of flow through the pools is probably substantially less than the displacement time indicated above. The accompanying diagram shows the estimated time required for the water in the river to reach various downstream points and is predicated on 50 per cent of the total complete displacement.

We then have these two factors which are of vital importance in enabling the Spokane River to free itself from its load of pollution before it reaches the Columbia:

1. The time which is shown from the accaccompanying curve to be about 40 days in low water.
2. The area of exposed water surface, including the pools back of the dams, which is estimated at about 250,000,000 square feet.

The rate of re-aeration of a stream depends on the amount of pollution it contains. The more it is polluted, the more rapidly it absorbs the oxygen of the air. The law which seems to be generally accepted is: If 20 per cent of the oxygen demand of a stream be satisfied in the first 24 hours, then 20 per cent of the remainder will be satisfied in the next 24 hours, and so on.

Studies made by the U. S. Public Health Service on the Mississippi River showed that re-aeration took place at the rate of five-tenths pounds of five-day B. O. D. per 1,000 square feet of surface per 24 hours. where the dissolved oxygen in the diluting waters was 60 per cent saturation. If this is true, then 250,000,000 square feet of exposed surface would be capable of supplying 125,000 pounds of oxygen per day, or about five times the 27,000 pounds required for Spokane sewage.

It is true that the dissolved oxygen in the Spokane River is somewhat higher than 60 per cent saturation and therefore the rate of re-aeration would be somewhat less. But even so, if we take the findings of the U. S. Public Health Service as applicable, we would be safe in expecting to find the waters of the river entirely recovered from its pollution load, considerably before it reaches the Long Lake Dam. Let us now see what actual analysis of the river revealed.

During 1933, 23 weekly samples were taken of the river at the low-water period, from June 6th to December 5th. These samples were analyzed for the following results: Five-day B. O. D., dissolved oxygen and total bacterial count on agar and colon.

We will assume in this paper that the five-day B. O. D. determination is an index of the extent to which the water in the Spokane River is able to rehabilitate itself in its flow from Spokane to the Columbia River.

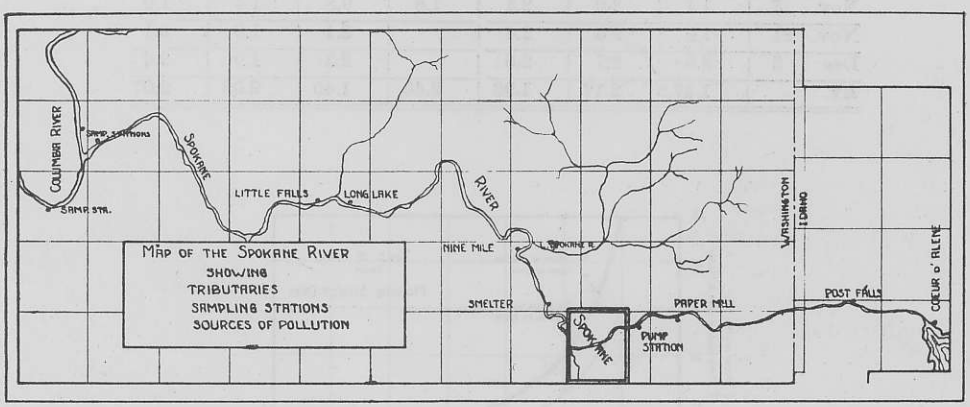
The average of these 23 samples taken are as follows:

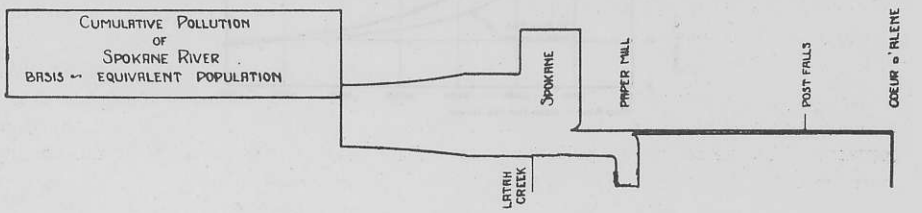
In the forebay of the City Power Plant above the city 1.47
At the head of the Nine Mile backwaters 2.17
At Nine Mile just above the dam 1.93
At the mouth of the Spokane River 1.40

The correct answer to a biological problem can only be had when sufficient data has been collected to justify a conclusion. The more data, the more nearly the right answer will be had, but no problem is complete without some kind of an answer, so with what data we have, the answer so far as B. O. D. studies are concerned, is that the Spokane River is the most heavily polluted as it enters the back waters of Nine Mile Dam, less heavily polluted at a point just above this dam and purer at its mouth than it is at the City Power Plant where it enters the city limits.

We then have two reasons to believe that the Spokane River at its mouth has entirely recovered its oxygen balance. First: From the findings of the U. S. Public Health Service, it is reasonable to expect. Second: From the average results of 23 samples it has actually taken place.

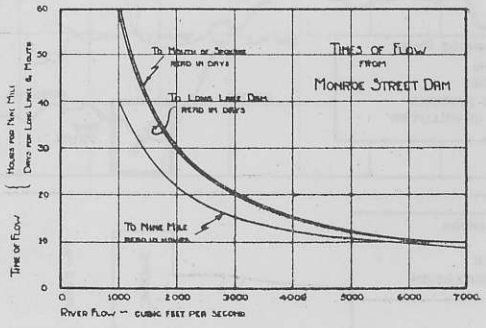
The scientific value of such studies as these can not be denied and it is the hope that the U. S. Public Health Service may be induced to take up these studies and carry them to completion, for there is no stream in the United States where the problem of self-purification is presented in as clean-cut a manner as is the case with the Spokane River.





BIOCHEMICAL OXYGEN DEMAND Five-Day Test 1933

Date of Observation	Pump Station	Smelter	Nine Mile	Nine Mile 10 Ft. Down	Mouth of Spokane	Upper Columbia	Lower Columbia
Jun. 6	0.05	2.65	0.64		0.62	2 53	2.5
Jun. 13	2.15	2.80	2.71		1.95	3.10	2.7
Jun. 20	1.5	2.1	2.6		1.8	3.6	3.3
Jun. 27	0.6	1.5	1.8		0.5	1.9	2.8
Jul. 3	1.4	1.8	1.2		1.2	4.0	3.5
Jul. 11	2.5	2.3	2.4		1.2	4.1	3.9
Jul. 18	1.4	1.8	1.5	2.2	1.6	2.8	2.2
Jul. 25	1.8	2.6	2.2	3.1	0.8	2.3	3.4
Aug. 1	1.7	1.8	1.6	2.0	1.1	2.5	2.5
Aug. 9	1.7	2.4	2.1	3.3	1.5	2.4	1.9
Aug. 15	1.5	2.3	1.1	2.3	1.5	1.9	0.9
Aug. 23	1.7	2.7	2.1	2.8	2.0	1.6	2.0
Aug. 28	0.8	2.0	2.3	2.4	1.8	0.8	1.5
Sep. 5	0.8	1.8	1.7	1.9	1.1	1.0	1.0
Sep. 12	1.9	1.4	1.8	2.6	1.5	1.1	1.4
Sep. 19	1.1		1.5	2.2	1.2	0.8	1.0
Sep. 26	1.5	2.5	1.6	2.4	1.3	1 4	1.1
Oct. 3	1.1	1.8	1.9	2.2	1.4	1.2	1 5
Oct. 10	1.2	2.2	1.7	2.2	1.0	1.1	1.1
Oct. 25	1.9	2.6	2.3	2.6	1.9	1.8	1.7
Nov. 7	1.1	2.0	2.3	1.8	0.8	1 4	1.0
Nov. 21	1.9	2.0	2.4		2.1	1.9	2.1
Dec. 5	2.5	2.7	2.6		2.3	1.9	2.6
Av.	1.47	2.17	1.93	2.40	1.40	2.05	2.07



DISSOLVED OXYGEN Parts Per Million 1933

Date of Observation	Pump Station	Smelter	Nine Mile	Nine Mile 10 Ft. Down	Mouth of Spokane	Upper Columbia	Lower Columbia
Jun. 6	9.60	11.68	10.35		10.10	13.05	12.60
Jun. 13	11.35	11.80	11 81		10.95	13.1	12.4
Jun. 20	10.4	11.7	11.2		10.7	13.3	12.9
Jun. 27	9.8	11.0	10.8		10.0	13.1	12.7
Jul. 3	10.2	11.4	10.8		10.9	13.9	13.7
Jul. 11	9.5	10.5	9.4		10.3	13.7	13.2
Jul. 18	9.0	10.1	9 2	9.3	10.2	13.2	12.6
Jul. 25	9.0	10.4	9.8	9.8	8.3	11.7	11.5
Aug. 1	8.7	9 5	8.4	8.8	9.2	11.5	11.5
Aug. 9	8.7	9.6	8.5	9.2	9.4	11.2	11.1
Aug. 15	8.5	9.3	8 0	8.2	9.3	10.8	9.7
Aug. 23	9.1	9.7	8.0	8.3	9.7	10.8	10.8
Aug. 28	8.7	9 3	8.3	8.0	9.5	10.6	10.4
Sep. 5	8.5	9.4	8.9	8.6	9.7	10.7	10.5
Sep. 12	9.0	9.5	8 8	8.9	10.0	11.1	10.4
Sep. 19	8.9		8.9	8.9	9.8	10.9	10.3
Sep. 26	9.2	9.9	9 5	9.4	10.2	11.2	11.1
Oct. 3	9.2	9.8	9.7	9.7	10.4	11.3	11.1
Oct. 10	9.2	9 8	9.4	9.2	10.5	11.2	11.0
Oct. 25	10.3	10.0	10.5	10.4	10.8	11.9	11.7
Nov. 7	11.2	12.3	12 2	12.0	11.6	12.7	12.4
Nov. 21	10.8	11.5	11.2		11.7	12.7	12.7
Dec. 5	11.3	11.9	11 4		11.6	13.2	12.9
Av.	9.57	10.4	9.82	9.25	10.20	12.04	11.7

GEOLOGICAL BULLETIN. Under date of February 15, 1937, Vol. 2, No. 5, of Professor George Beck's Geological Bulletin, appears. It is a little three-column sheet packed full of news of paleontology of central Washington. It is a bit difficult to be judicially calm about the work of this tireless worker. What he has done for this section in less than a decade in making geological history would seem much for a life-time. Seven or eight years ago he took the writer out from his laboratory in the Ellensburg Normal School to the Columbia River at Vantage and showed slivers of petrified wood found on the slopes of the canyon. These he followed back as a prospector would follow "float" until, finding here and there a buried stump, he has revealed forest on forest connecting the Miocene with the present. A CCC camp of workers have converted this area of rocky slopes into a

DISSOLVED OXYGEN

Per Cent Saturation

1933

Date of Observation	Pump Station	Smelter	Nine Mile	Nine Mile 10 Ft. Down	Mouth of Spokane	Upper Columbia	Lower Columbia
Jun. 6	96.4	117.2	103.9		97.9	124.2	121.0
Jun. 13	116.8	122.1	122.1		114.6	126.0	121.9
Jun. 20	110.0	123.6	119.8		114.5	129.0	126.7
Jun. 27	107.0	120.0	118.0		108.0	128.5	126.0
Jul. 3	111.5	124.5	118.0		116.5	140.0	139.0
Jul. 11	107.0	117.0	107.0		114.7	137.5	134.0
Jul. 18	102.5	111.6	103.5	103.9	105.6	136.6	139.0
Jul. 25	100.2	112.3	111.6	111.6	96.3	122.5	121.9
Aug. 1	95.1	99.5	94.5	99.1	104.4	121.8	120.4
Aug. 9	97.2	102.8	94.8	103.5	106.9	119.7	119.0
Aug. 15	95.8	101.5	89.2	96.0	103.5	112.3	106.0
Aug. 23	99.3	100.6	87.4	96.3	107.0	116.7	116.7
Aug. 28	96.0	98.5	91.7	88.4	105.0	114.7	111.1
Sep. 5	90.8	98.4	95.2	92.0	103.8	112.2	110.0
Sep. 12	94.2	99.4	92.1	93.2	108.0	116.2	107.7
Sep. 19	92.3		92.3	92.3	102.5	111.8	105.5
Sep. 26	90.3	94.0	90.2	89.2	100.2	110.1	109.2
Oct. 3	91.4	95.3	95.2	95.2	104.5	111.0	109.0
Oct. 10	92.3	97.4	94.3	92.2	102.1	110.0	106.7
Oct. 25	100.1	97.2	102.0	101.1	101.5	109.5	108.8
Nov. 7	102.9	113.0	113.2	111.4	102.3	111.7	110.0
Nov. 21	96.8	103.1	101.4		105.3	109.0	110.2
Dec. 5	95.0	103.1	97.2		99.4	110.2	109.3
Av.	98.3	106.9	101.5	97.7	105.4	119.3	116.9

great outdoor museum: a Gingko National Monument. Not satisfied with these, he is now filling his bulletins with Rhinoceri, Camels, Elephants, Hiparion, Bison and many smaller mammals represented by bones found here and there in the Great Bend, Yakima and Kittitas sectors by many delighted contributors.

In progress in The Mineralogist of Portland, Oregon, is a series of articles on 'determination' of petrified woods. Soon to appear will be "Camels of the Columbia Plateau" from Professor Becks' pen.

Oh, George, please give some of us envious ones, who exhaust ourselves with our daily round from home to classroom, "a shot of the same" which enables you to have eyes to see in every part of an area as big as Indiana and energy left to write and teach.