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TITLE

RECOMMENDED LIMIT ON ADDITION OF DICHROMATE TO THE COLUMBIA RIVER

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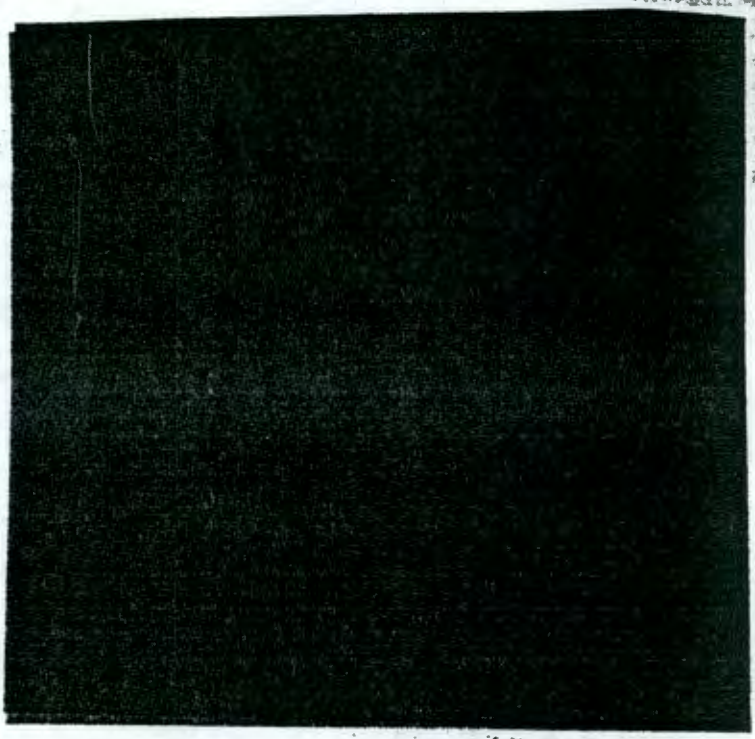

RECOMMENDED LIMIT ON ADDITION OF DICHROMATE TO THE COLUMBIA RIVER

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by

R. F. Foster

Aquatic Biology
BIOLOGY OPERATION

April 17, 1957

SPECIAL RE-REVIEW
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ABSTRACT

Specifications for the water used to cool the reactors call for the addition of 2.0 ppm of $Na_2Cr_2O_7.2H_2O$, equivalent to 0.7 ppm as Cr(VI). The maximum permissible concentration of Cr(VI) in Columbia River water is considered in relation to drinking water standards, toxicity to irrigated crops, and toxicity to river life. The limiting factor appears to be toxicity to important species of fish. It is recommended that the monthly average concentration of Cr(VI) in the Columbia River not exceed 0.02 ppm. Fluctuations in flow of the Columbia River which may result from Priest Rapids Dam should not affect this recommendation.

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RECOMMENDED LIMIT ON ADDITION OF DICHROMATE TO THE COLUMBIA RIVER

INTRODUCTION

Sodium dichromate is added to the reactor cooling water to reduce the rate of corrosion on tubes and the jackets of fuel elements. When this cooling water enters the Columbia River as effluent, a substantial dilution of the dichromate is accomplished. Never the less, chromium is a toxic substance and the quantities discharged into the river warrant close attention. The limiting factor for the concentration of Cr(VI) in Columbia River water could be either: (a) the permissible quantity for domestic water supplies, (b) the quantity which is toxic to irrigated crops, or (c) the quantity which is toxic to river organisms.

Permissible Concentration in Drinking Water

The permissible quantity for domestic water supplies is established by the U. S. Public Health Service Drinking Water Standards of 1946 (1) which sets a limit of 0.05 ppm for hexavalent chromium.

Toxicity to Irrigated Crops

The toxicity of dichromate to plants has been studied by the Plant Nutrition and Microbiology Operation. Plants grown in nutrient solution show the greatest sensitivity to dichromate, and definite toxic symptoms were produced at 0.1 ppm Cr(VI) by Rediske (2). When applied to the surface of soil, toxicity occurred at a concentration of 18 mg Cr(VI)/ft^2 (2). Even if the concentration of dichromate in the soil increased with time because of percolation effects in poorly drained soil, it would take 15 to 20 years of irrigation with Columbia River water containing on the order of 0.012 ppm

Cr(VI) before such a toxic level would result. Furthermore, recent experiments (3) show that for conditions more closely approximating those in the field, toxicity to plants probably does not occur until the concentration in the soil is considerably above 18 mg Cr(VI)/ft^2 and also that the concentration of the dichromate in the soil is greatly reduced by dispersion. This dispersion is apparent in plots watered with 100% effluent for five years since there has been no detectable build up of chromium in the surface layers (3, 4). From these observations it can be concluded that irrigation of crops is not a limiting factor for Cr(VI) concentration in Columbia River water.

Toxicity to River Organisms

The toxicity of hexavalent chromium to river organisms has been studied by the Aquatic Biology Operation. Tests have been run with young trout and salmon with reactor process water, reactor effluent, and with addition of sodium dichromate to Columbia River water. Results of these tests are summarized in Table 1.

TABLE 1

Toxicity of Dichromate to Young Trout and Salmon

Test			PPM Cr(VI)* to Cause Effect				
			Retarded Growth		Increased Mortality		
Kind of Water	Kind of Fish	Reference	None	Borderline	None	Borderline	2X Contro
Reactor Influent	Chinook Salmon	(5)	-	0.021	0.035	-	0.070
Reactor Area Effluent	Salmon and Trout	(6,7,8,&9)	0.021**	0.035	0.021	0.035	0.070
$Na_2Cr_2O_7$ in River Water	Rainbow Trout	(10)	0.013	0.020	0.041	0.076	0.18
$Na_2Cr_2O_7$ in River Water	Chinook Salmon	(10)	0.013	0.020	0.041	0.076	0.18
$Na_2Cr_2O_7$ in River Water	Chinook Salmon	(11)	0.016	0.023***	0.023	0.030	0.080

* Based on addition of the commercial grade salt as used in the process water for the reactors. Chemical analyses of the experimental water sometimes show the concentration to be slightly less.

** Growth-retardation is obscured in tests involving effluent since growth is stimulated by the higher temperatures.

*** When the dichromate addition was stopped, the effect did not persist and the fish tended to "catch up" to the size of the controls.

These results indicate that, for juvenile salmon and trout, Cr(VI) causes no adverse effect at about 0.01 ppm; at a concentration of 0.02 ppm a borderline effect on growth may result, but the damage is not permanent; and at 0.1 ppm excessive mortality results.

The limiting factor for the concentration of Cr(VI) in the Columbia River appears to be its effect on aquatic organisms. On the basis of tests run on young salmon and trout, a limit of 0.02 ppm Cr(VI) is recommended. The fish can apparently tolerate this concentration indefinitely without significant inhibition, but this limit does not contain a factor of safety. Twice this concentration causes significant retardation of growth and a measurable increase in mortality.

The salmon and trout used for these tests represent not only the most valuable species of fish in the Columbia, but also those which are believed to be most sensitive to the dichromate. Current test with young whitefish indicate that their tolerance is not greatly different from that of the salmon. The relative sensitivity of the important fish-food organisms is not yet known, but is now under study. Since good populations of the bottom organisms are now present in an area below the outfall of the 100-F reactor where the concentration of Cr(VI) has been as high as 0.02 ppm, the sensitivity of these forms is not, at this time, considered to be more limiting than the sensitivity of the fish.

In practice, the recommended limit should apply to the average concentration over a period of two weeks or, possibly, a month. Short term exposures to concentration at least as high as the limit for drinking water would apparently do no harm, provided the integrated exposure did not exceed 0.02 ppm. This recommendation is based on the results of a recent test (12) which showed that dichromate was somewhat more toxic to young salmon if administered at a constant rate than if the same total quantity was administered intermittently. This

result is quite favorable to the Hanford operation since it may simplify specifications for dichromate addition in that hour to hour or day to day fluctuations in the flow of the Columbia River do not have to be considered and we need not be greatly concerned about high concentrations in effluent channels in the river since it is reasonable to assume that most fish will spend only a part of their time in such high concentration.

Dichromate Addition v.s. Flow of the Columbia River

Specifications for reactor cooling water (13) call for the addition of 2.0 ppm of $Na_2Cr_2O_7 \cdot 2H_2O$, equivalent to 0.7 ppm as Cr(VI). During January and February of 1957 the average flow of process water through the eight reactors was about 9,000 gallons per second. Since the average flow of the river during this period was 575,000 gallons per second, the average concentration of Cr(VI) must have been close to 0.01 ppm. On individual days when all reactors were operating and minimum flow occurred in the Columbia River, concentrations as high as 0.016 ppm occurred. Chemical analyses of water pumped from the Columbia at the 100-F Area had an average concentration of about 0.012 ppm Cr(VI) during January and February of 1957. This is in good agreement with the above calculations considering the imperfect mixing of the effluent in this section of the river.

If 0.02 ppm is selected as the upper limit for Cr(VI), the maximum permissible amount of sodium dichromate which may be added to the Columbia River can be computed for each month on the basis of river discharge records. The computed values are shown in Table 2 for river flows estimated by the Bonneville Power Administration (14). For the critical flow year (1936-1937), upon which estimates of primary hydroelectric power are based, the permissible amount of dichromate could be as low as 470,000 to 600,000 pounds for the months of April and September. For more typical months during the normal low-flow season

TABLE 2

Permissible Addition of Sodium Dichromate to the Columbia River --
Based on Recommended Maximum Permissible Concentration of 0.02 ppm of Cr(VI)

Month	Year with "Normal" Flow			Year with Minimum Flow		
	River Flow C.F.S.*	Pounds of $Na_2Cr_2O_7.2H_2O$		River Flow C.F.S.**	Pounds of $Na_2Cr_2O_7.2H_2O$	
		Per Second	Thousands Per Month		Per Second	Thousands Per Month
January	70,520	0.250	670	65,190	0.232	621
February	71,710	0.254	614	61,920	0.220	532
March	71,360	0.253	678	55,870	0.198	530
April 1-15	84,040	0.298	772	51,010	0.181	235
16-30				44,430	0.158	205
May	103,770	0.368	986	90,880	0.322	862
June	263,250	0.935	2,424	187,270	0.664	1,721
July	182,270	0.647	1,733	145,720	0.516	1,382
August	107,450	0.382	1,023	92,680	0.329	881
September 1-15	81,330	0.288	746	76,030	0.270	350
16-30				60,810	0.216	280
October	69,420	0.246	659	55,280	0.196	525
November	67,260	0.239	619	54,930	0.195	505
December	70,720	0.251	672	57,930	0.206	552

* Figures from "Priest Rapids Hydroelectric Development - Columbia River, Washington", Volume II of Hydroelectric Projects Report issued by Public Utility District No. 2 of Grant County, Washington, June, 1955. Exhibit II-B-1.

** Figures from publication cited above for the minimum water year (July 1936 - June 1937).

(October through March), on the order of 600,000 to 700,000 pounds could be added. For the month which included the peak of the freshet (usually June) over 2,000,000 pounds could be added.

Wide fluctuations in the amount of water released during different parts of the day may occur when Priest Rapids dam is in operation (14). At a mean discharge of [illegible] c.f.s. in the Columbia as a whole, the release from Priest Rapids may be as low as [illegible] c.f.s. at 4:00 am and as high as 100,000 c.f.s. at 6:00 pm. While such a fluctuation would materially reduce the area of the river bottom which could support aquatic life, in all probability the diurnal fluctuation which would result in the concentration of chromium would not increase the toxicity hazard to the organisms. This interpretation is based on the test which showed that chronic exposure was somewhat more damaging than intermittent exposure to equivalent amounts of chromium (13). The values in Table 2 need not, therefore, be modified to reflect the hour-to-hour or even day-to-day changes which will occur in the river flow.

So far as the writer has been able to determine, there are no plans for modifying the flow of the Columbia River during the construction of the dams at Priest Rapids which need be taken into account in establishing limits on chromium addition.

The amounts of dichromate listed in Table 2 apply to this section of the river as a whole. If substantial amounts of chromium are added by other sources up river, the amount which could be added by the Hanford Operation would be reduced accordingly.

LITERATURE CITED

1. U. S. Public Health Service Drinking Water Standards, 1946. Jour. A.W.W.A. 38, p. 361.

2. Rediske, J. H., "Chromium toxicity in plants," Document HW-42969, (1956) (UNCLASSIFIED).

3. Cline, J. F. and C. H. Hemphill, unpublished data.

4. Cline, J. F., A. A. Selders, and J. H. Rediske, "Chronic effects of reactor effluent water on cereal plants - 1954," in "Biology Research - Annual Report 1954," Document HW-35917, p. 28 (1955) (OFFICIAL USE ONLY).

5. Olson, P. A., "Effect of sodium dichromate in reactor cooling water on young chinook salmon," Document HW-44257, (1956) (CONFIDENTIAL).

6. Olson, P. A., and R. F. Foster, "Reactor effluent monitoring with young chinook salmon - 1954," in "Biology Research - Annual Report 1954," Document HW-35917, p. 11 (1955) (OFFICIAL USE ONLY).

7. Olson, P. A. Jr., and R. F. Foster, "Effect of pile effluent water on fish," in "Biology Research - Annual Report 1951," Document HW-25021, p. 41 (1952) (OFFICIAL USE ONLY).

8. Foster, R. F., and P. A. Olson, Jr., "Effect of reactor effluent water on young silver salmon," in "Biology Research - Annual Report 1952," Document HW-28636, p. 31, (1953) (UNCLASSIFIED).

9. Olson, P. A. and R. F. Foster, "Reactor effluent monitoring with young chinook salmon - 1953," in "Biology Research - Annual Report 1953," Document HW-30437, p. [illegible] (1954) (UNCLASSIFIED).

10. Olson, P. A. and R. F. Foster, "Effect of chronic exposure to sodium dichromate on young chinook salmon and rainbow trout - 1955," in "Biology Research - Annual Report 1955," Document HW-41500, p. 25 (1956) (UNCLASSIFIED).

11. Results obtained by P. A. Olson during the winter of 1955 and spring of 1956, unpublished.

12. Olson, P. A. and R. F. Foster, "Further studies on the effect of sodium dichromate on juvenile chinook salmon," in "Biology Research - Annual Report 1956," Document HW-47500 (1957) (UNCLASSIFIED) (In preparation).

13. "Process Standards - Reactor Cooling Water - November 1954," Document HW-27155 - Revised, p. 3-1 (SECRET).

14. Public Utility District No. 2 of Grant County, Washington, "Priest Rapids Hydroelectric Development - Columbia River Washington", Volume II, Hydroelectric Projects Report, p. II-B-5, Exhibit II-B-1, and Exhibit II-J-2 (1955).