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COLOR REMOVAL FROM SURFACE WATERS BY HYPOCHLORITE: FIELD TESTS ON WATER AT KOTZEBUE AIR FORCE SITE

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ABSTRACT

A practical method was sought for removing the unacceptably high color and chlorine demand from the surface water source used at Kotzebue Air Force Site. Earlier laboratory tests of this water had indicated that treatment with 10 to 40 ppm chlorine would produce satisfactory water, with 95% color removal. Field tests were conducted at the site in 1962 and 1963. Treatment with 32 ppm chlorine reduced color from 70 cobalt units to 10-15 units in 24 days, with a final chlorine residual of 2 ppm. Treatment with 21 ppm chlorine reduced color to 20 units in 82 days, at which time the chlorine residual was zero and recoloration began. Although results of the field tests did not entirely agree with laboratory findings, the 32 ppm chlorine dose was found to be a satisfactory, simple and practical method of treatment. Reduction of chlorine residual to an acceptable level occurred within 24 days following treatment.

PUBLICATION REVIEW

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FIELD TESTS ON WATER AT KOTZEBUE AIR FORCE SITE

SECTION 1. INTRODUCTION

Many remote U. S. Air Force stations in Alaska use surface waters as their source of supply. These waters generally contain large amounts of dissolved or colloidal organic matter, which impart high color and create a large chlorine demand. An effective method of treating this type of water was sought, with the following objectives in view: (1) reduction of color to acceptable levels; (2) satisfaction of chlorine demand so that a chlorine residual could be maintained in the system; and (3) simplicity of operation, requiring minimum maintenance and supervision.

Laboratory studies performed on samples of the water by Baumgartner showed a maximum of 50% color removal by the use of carbon filters (1). Further laboratory studies showed satisfactory removal of color and chlorine demand by treatment with 10 to 40 ppm chlorine (2). On the basis of these results, Baumgartner recommended a chlorine dose of 30 ppm and a retention time of 60 days.

Description of system and raw water. The year's water supply for the Kotzebue Air Force Site is collected during the spring thaw period, when the adjacent watershed produces runoff in nearby June Creek. Water is pumped from a small impoundment in the creek into a 75, 000-gallon storage tank which overflows into a 2, 000, 000-gallon heated storage tank. Pumping is done in June or July and is completed in approximately 10 days. The water is chlorinated with liquid hypochlorite as it is pumped from the 75, 000-gallon tank into a pressure tank on the distribution system.

The 2, 000, 000-gallon tank provides the winter supply for the site. Storage is necessary because June Creek dries up early in the fall when freeze-up occurs. After the 2, 000, 000-gallon tank is filled, about 6, 000 gallons from it are pumped daily into the 75, 000-gallon tank to meet the water needs of the site for the rest of the summer. In the early fall, shortly before freeze-up, the 2, 000, 000-gallon tank is refilled with water from June Creek, and this water is used throughout the winter. The water in the large tank is electrically heated to 5 to 10° C to prevent freezing.

This procedure was varied in 1963. After the large tank was filled in July, it was not used during the summer. Instead, raw water from June

Creek was pumped directly to the 75, 000-gallon tank and thence to the distribution system, with chlorine added for disinfection at the June Creek pumping station.

At the time of the field tests, the raw water had a median pH of 6. 8 (range of 6. 8 to 7. 2), a median apparent color of 70 cobalt units (range of 65 to 115) and a temperature of 10 to 12° C.

Objectives of this study. With Baumgartner's laboratory studies as a guide, field tests of the hypochlorite method of color removal were made on the Kotzebue Air Force Site water supply. The objectives of the field study were:

1. To determine the optimum chlorine dose under field conditions for satisfactory reduction of color and satisfaction of chlorine demand.

2. To determine the necessary retention time under field conditions for reduction of chlorine residuals to acceptable levels.

3. To determine the practicability of this method of treatment.

SECTION 2. PROCEDURES

Field tests were carried out on the water supply in 1962 and 1963, using 70% HTH as the chlorine source. In 1962 the hypochlorite was applied by solution feed. A small amount of the chlorine was added as the water left June Creek. The major portion of the chlorine was added to the water as it overflowed into the 2, 000, 000-gallon tank. Pumping began on 21 June, and the 2, 000, 000-gallon tank was full by 3 July. A total dose of 32. 4 ppm chlorine was applied during pumping.

In 1963 a similar procedure was used except that the total chlorine dose was 21. 5 ppm, and approximately equal portions of the chlorine were added at the two application points.

Color and chlorine residual tests were made periodically on the stored water following treatment. Color tests were made with a Hellige aqua-tester and standard disc "Color of Water II."

Chlorine residual tests were made by iodometric titration and with an orthotolidine chlorine comparator. Residuals given in this report are immediate chlorine readings on the comparator.

A color reduction to 20 units first was adopted as the criterion for evaluating effectiveness of treatment in color removal, based on the Public Health Service standard for color at that time. During the study, the USPHS standard for color in water was revised to 15 units (3), so this figure was adopted as the criterion. Ability of the water to maintain a chlorine residual over an extended period was the criterion for evaluating satisfaction of chlorine demand.

SECTION 3. RESULTS OF FIELD TESTS

Table I summarizes the results of hypochlorite treatment of the water in two consecutive years.

Treatment with 32.4 ppm chlorine (in 1962) gave satisfactory color removal within 24 days, and a satisfactory chlorine residual was maintained. Unfortunately, the 2,000,000-gallon tank had to be replenished with raw water beginning 28 August, which dropped the chlorine residual to zero. Thus persistence of the chlorine residual could not be determined. However, the low rate of chlorine loss after 13 days indicated conditions approaching stability. Table I shows that the chlorine residual was reduced to 2 ppm within 24 days.

Treatment with 21.5 ppm chlorine (in 1963) gave some color reduction, but the water did not maintain a satisfactory chlorine residual. In both tests, recoloration occurred after the chlorine residual reached zero.

Table II shows chemical analyses of the water in the 2,000,000-gallon tank after treatment in both years and of the raw water before treatment.

SECTION 4. DISCUSSION

Comparison with laboratory tests. The field test results varied from the laboratory test results in two ways, which are summarized in Table III.

1. Less color removal in the field tests: a maximum of 80% removal as compared to 95% removal in the laboratory tests.

2. More rapid reduction of chlorine residuals in the field tests.

TABLE I

COLOR REDUCTION IN KOTZEBUE AIR FORCE SITE WATER

Test (Dates of filling large tank)	Chlorine Dose (ppm)	Number of Days After Chlorine Application*	Color (cobalt units)	Chlorine (ppm)
21 June-3 July 1962	32.4	13	10 to 20	3
		24	10 to 15	2
		**		
		105	30	0
		228	40	0
2-13 July 1963	21.5	13	25	<0.1
		82	20	0
		200	30	0

* Measured from midpoint of time period required to fill large tank.

** 355,000 gallons of raw water added to 2,000,000-gallon tank without further chlorine treatment.

TABLE II

CHEMICAL ANALYSES OF WATER AT KOTZEBUE AIR FORCE SITE

	Raw Water July 1963 (grab sample)	Treated Water in 2,000,000-Gallon Tank	
		1962	1963
Chlorine Dose (ppm)	---	32.4 ppm	21.5 ppm
Number of Days After Treatment	---	13 days	1 day
Chlorine (ppm)	0	3	0.75
Color (cobalt units)	70	10-20	25
pH	6.7	7.05	---
Total Solids (ppm)	70	151	101
Apparent Organic Matter (ppm*)	51	98	77
Hardness (ppm $CaCO_3$)	34	78	65
Calcium (ppm Ca)	9	24	17
Iron (ppm)	0.4	1.1	0.5
Chlorides (ppm)	9	20	16

* Loss on ignition at 500° C: equivalent to "Volatile Solids" except for use of nonstandard ignition temperature (500° vs standard 600° C)

TABLE III

COMPARISON OF LABORATORY AND FIELD FINDINGS

Chlorine Dose (ppm)	% Color Removal After 13 days **		Free Chlorine Residual Remaining After 13 days **	
	Expected Reduction*	Actual Reduction	Expected (ppm)*	Actual (ppm)
32.4	95%	79%	8	3
21.5	93%	64%	4	<0.1

* Interpolated from USPHS (3), Figures 4 and 5.
** Measured from midpoint of time period required to fill large tank.

Several factors could account for these differences. The laboratory tests were run at an average temperature of 24° C, while the field tests were made at the ambient temperature of the raw water, 10 to 12° C. The chlorine and color analyses were done by different methods in the laboratory and field tests.

However, the most likely explanation of the difference in results is the fact that the laboratory tests were made on water which had already been treated with 15 ppm chlorine the previous summer and had an initial color of 40 units. Therefore, the laboratory dose of 30 ppm made a total dose of 45 ppm.

If color removal is measured in terms of amount rather than percentage removed, the field tests compare more closely to the laboratory tests, as shown in Table IV. Also, the chlorine residual die-away curve in the field test, using 32.4 ppm chlorine, coincided almost exactly with the curve on the laboratory test, using 20 ppm chlorine. If one takes into account the earlier treatment of the laboratory samples, the effect of the total 35 ppm dose (15+20) coincides very closely with that of the 32.4 ppm field test dose. The difference in color remaining (nearly 0 in the laboratory tests compared to 10-15 units in the field tests) could be accounted for by the fact that the laboratory tests were made on water which had several months settling time, while the field tests measured apparent color (including turbidity) on samples which had settled only 24 days.

TABLE IV

COLOR REMOVAL IN LABORATORY AND FIELD TESTS
KOTZEBUE AIR FORCE SITE WATER

Approximate Chlorine Dose (ppm)	Total Color Removal in 13 Days (cobalt units)	
	Laboratory Tests	Field Tests
30	38	--
32.4	--	55
20	37	--
21.5	--	45

In both years, recoloration appeared in the 2,000,000-gallon tank after the chlorine residual reached zero. No explanation for this is apparent from the data collected. Baumgartner (2) hypothesized that recoloration may be due to contact with sediment in the tank. It should be noted that with the 32.4 ppm chlorine dose, the residual dropped to zero only after the large tank was refilled with approximately 355,000 gallons of raw water. This was undoubtedly at least partly responsible for the increase in color in the 1962 test.

Comparison of the raw and treated water (Table II) did not reveal any adverse effects on the water from the treatment.

The method of application posed no particular problems. In treating the water, the hypochlorite solution was mixed approximately in the proportion of one pound HTH per gallon of water. Some difficulty was experienced in 1962 due to clogging of the hypochlorinators. This trouble was eliminated in 1963 by using two 30-gallon plastic containers, mixing the solution in one and decanting the clear supernatant into the other. The hypochlorinator drew from the container with the clear solution.

Acceptability of water to site personnel. In 1963, the 21.5 ppm chlorine dose reduced color to 20 units, and recoloration during the winter raised the color to 30 units. This water was considered acceptable to the site personnel, since no complaints were received by the base engineer. However, since this treatment left the chlorine demand unsatisfied, it cannot be considered adequate. In addition, it must be remembered that the site had used relatively untreated water (color 70) the summer before, and the change-over to the winter supply with a color of 20 to 30 probably would have been sufficient improvement to eliminate complaints.

In 1962, the chlorine residual of 2 ppm after 24 days retention did not create taste problems. The base engineer reported:

> "The water from the beach tank (the 2,000,000-gallon tank) was really nice when we were using it. It was crystal clear and we didn't have to add any chlorine. The chlorine residual was just under 2.0 and was dropping very slowly. The color was between 10 and 15 at the time we started using the water. I'm hoping that the amount of water we added to recap the beach tank was not enough to appreciably change the color of the water." (4)

On the basis of this report, the 2 ppm chlorine residual was considered acceptable. This residual also made it unnecessary to rechlorinate the water as it was pumped from the large tank to the 75,000-gallon tank and the distribution system, thus reducing maintenance time. As shown in Table I, the raw water subsequently added to the large tank did increase the color significantly and also reduced the chlorine residual to zero.

SECTION 5. CONCLUSIONS

1. Field tests confirm earlier laboratory conclusions that color and chlorine demand in this water can be reduced to a satisfactory level by chlorination.

2. A 32 ppm chlorine dose is indicated for the Kotzebue Air Force Site water supply. This dose will reduce color to 10 to 20 cobalt units in 13 days and maintain an adequate chlorine residual for an extended period.

3. No adverse effects to the water from this treatment were observed.

4. The chlorine residual from a 32.4 ppm chlorine dose drops to an acceptable level (2 ppm) within 24 days from the midpoint of treatment.

5. A 21.5 ppm dose did not give adequate color reduction or satisfaction of chlorine demand.

6. Application of treatment was simple and easy to control.

SECTION 6. RECOMMENDATIONS

1. When the 2,000,000-gallon tank is filled each year, it should be treated with 32 ppm chlorine (approximately 800 pounds of 70% HTH or equivalent).

2. If additional water is added to this tank later in the season, it should be similarly treated with 32 ppm chlorine as it is added.

3. Chlorine solution should be mixed at no greater proportion than one pound HTH per gallon of water, in corrosion-resistant containers. The hypochlorinator should pump from a clear hypochlorite solution. To obtain a 32 ppm chlorine dose with this solution and the existing 8,000-gallon-per-hour raw water pump, the hypochlorinator should have a capacity of at least 75 gallons per 24 hours.

4. Test apparatus for color and chlorine should be used routinely for proper monitoring of the treatment process.

REFERENCES

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