

Detecting Chromium Contamination in Natural Waters

Background

Metal ions are frequently introduced into natural waters as waste from various industrial processes. Many of these metal ions are toxic to humans and release of these substances must be monitored and controlled carefully.

Chromium is found in two ionic forms, Cr (III) and Cr (VI). Cr (III) is much less toxic than Cr (VI) and is rarely found in potable waters. Cr (VI) which is more commonly found in water is toxic to humans. When in aerosol form, Cr (VI) has been shown to damage the skin and upper respiratory system and cause lung cancer.¹ Although the toxic effects of this ion in drinking water have not been well documented, it is suspected to be a carcinogen.

Many industries utilize Cr (VI) in chromic acid and other forms. The chrome-plating industry uses chromic acid in the electro-plating process. Cr (VI) ions can be present in the waste water of this industry. Chromic acid is also added to the water used in industrial cooling towers to inhibit metal corrosion. The EPA recently banned Cr (VI) from use in 37,500 building roof cooling towers that leaked coolant into the air causing an estimated 20 cancer deaths.² Cr (VI) is also found in paints, pigments, tanning agents, inks, fungicides and wood preservatives.³

The maximum permissible level of Cr (VI) allowed to be released into waterways is 50 µg/L. The level in drinking water is much lower. A level higher than 3 µg/L is considered suggestive of industrial pollution.

In this experiment you will generate a calibration curve for detection of Cr (VI), solve a Cr (VI) pollution mystery and examine some methods by which industry can lower Cr (VI) concentration prior to releasing their waste water.

Procedure

I. Preparation of Standards

1. Prepare six standard solutions in large test tubes which can accommodate 15-20 mL of solution. Mix the quantities of Cr (VI). Mix the quantities of Cr (VI) solution and 0.18 M sulfuric acid given in the table below to make solutions 1-6.

Soln #	1	2	3	4	5	6
Cr (VI), mL	0.0	0.4	1.0	2.0	4.0	10.0
H ₂ SO ₄ , mL	10.0	9.6	9.0	8.0	6.0	0.0

2. Into each test tube pipet 0.5 mL of diphenylcarbazide solution. Mix the contents of the test tubes and let them stand for 5 minutes for color development.

3. Measure the absorbance of each sample at 540 nm and plot a standard curve. For the blank, use test tube 0. The absorptivity for the diphenylcarbazide-Cr (VI) complex is $40,000 \text{ Lg}^{-1}\text{cm}^{-1}$ at 540 nm.⁴

II. Determination of Chromium Concentration in Water Samples

1. Prepare a water sample for testing by placing 10.0 mL of water in a test tube. Test a sample of tap water and the sample labeled polluted water.
2. Add 12 drops of 3 M sulfuric acid to the sample.
3. Pipet 0.5 mL of diphenylcarbazide solution into the test tube and allow 5 minutes for color development.
4. Determine the amount of Cr (VI) present by measuring the absorbance of the sample at 540 nm of Cr (VI)

III. Reducing Cr (VI) Levels for Disposal

(A) Dilution Method

1. The maximum permissible level of Cr (VI) allowed to be released is 50 $\mu\text{g/L}$. Assume that an industry has 100 L of Cr (VI) polluted water containing 0.127 mg/L of Cr (VI). Calculate how many liters of chromium-free water must be mixed with the polluted water so that it can be released.

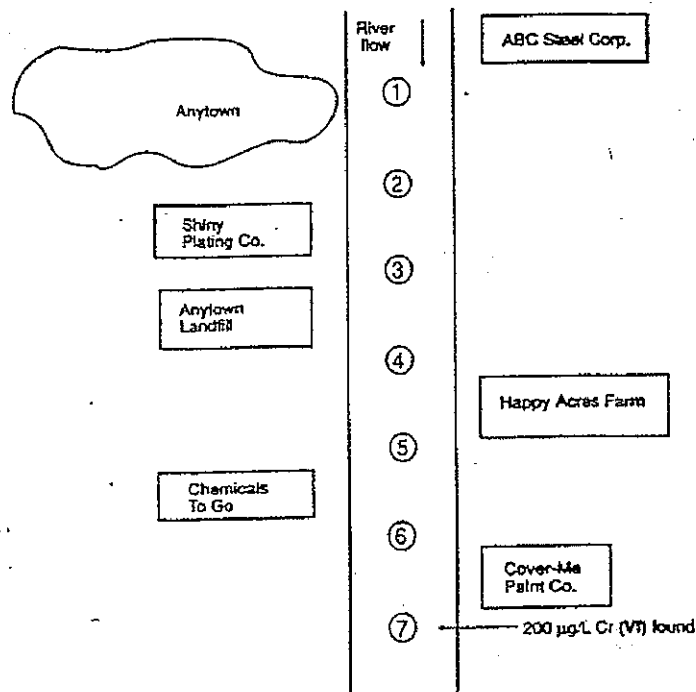
(B) Reduction Method

1. Cr (VI) can be easily reduced to Cr (III). A maximum permissible level of Cr (III) of 1,000 $\mu\text{g/L}$ may be released into natural waters.
2. Take a sample of the polluted water and add 5 drops of ascorbic acid solution (a mild reducing agent). Swirl the mixture and determine the Cr (VI) spectrophotometrically.

Solving a Water Pollution Mystery

Scenario

Anytown is located on a river. There are several industrial plants located on the river near Anytown. The map below shows Anytown and the region surrounding it. A sample of water collected at the site labeled 7 on the map by a student in an environmental chemistry class at Anytown U. was found to have $200\ \mu\text{g/L}$ of Cr (VI), an unusually high level. The goal of this investigation is to locate the source of the pollution. You are to test samples collected at sites 1-6 and from your analysis try to pinpoint the source of the contamination. You will be expected to write a memo exposing the source of the contamination and possible ways for the culprit to clean up its waste discharge along with a press release to the Anytown Times.



Map of Anytown and surrounding area—site of Cr(VI) pollution.

References

1. Varma, M.M.; Serdahely, S.C.; Katz, H.M. *J. Envir. Health* **1976**, 30, 90-100.
2. Cooper, M. *NCI Cancer Weekly*, Jan 15, 1990, p. 12.
3. *Chromium*, National Academy of Sciences, Washington, D.C., 1974.
4. *Standard Methods for the Examination of Water and Wastewater*, 17th ed., American Public Health Association: Washington, D.C.1989.