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Application of Heavy Metal Detection Technology in Environmental Water Quality Analysis

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Abstract: Water contains a large number of inorganic metal compounds, which generally exist in the form of metal ions. Especially when the concentration of metal ions in water exceeds a certain value, its toxicity is greater. Its toxicity is related to metal species, physical and chemical properties, concentration, valence and metal ion morphology. Therefore, the determination of metal elements is an important part of water quality monitoring project. Due to the different toxicity of different metal ions, it is necessary to determine the total amount of heavy metals in water. Monitoring of metal compounds focuses on toxic metal ions such as mercury, cadmium, chromium, lead, copper and zinc. Common monitoring methods include spectrophotometry, atomic absorption spectrometry, polarography and titration.

1. Introduction

Water contains a large number of inorganic metal compounds, which generally exist in the form of metal ions. Some metal elements are necessary for human health, such as sodium, potassium, calcium, magnesium, trace iron, manganese, selenium, tin, drill and so on. Some are harmful to human health, such as lead, cadmium, mercury, barium, arsenic, nickel and so on. Especially when the concentration of metal ions in water exceeds a certain value, its toxicity is greater. Its toxicity is related to metal species, physical and chemical properties, concentration, valence and metal ion morphology. Metal elements can also be rapidly enriched through the food chain and biological amplification, leading to a sharp increase in toxicity. Even beneficial metal elements can produce serious toxicity if their concentration exceeds a certain value. Therefore, the determination of metal elements is an important part of water quality monitoring project. Monitoring of metal compounds focuses on toxic metal ions such as mercury, cadmium, chromium, lead, copper and zinc. Common monitoring methods include spectrophotometry, atomic absorption spectrometry, polarography and titration.

2. Determination of mercury

Mercury and its compounds belong to highly toxic substances, especially organic mercury compounds, which enter the human body from the food chain and act on the human body through biological enrichment, such as Minamata disease in Japan. Natural water contains very little mercury and generally does not exceed 0.1 mg/l. The standard limit of drinking water in China is 0.001 mg/l, and the maximum allowable concentration of mercury in industrial sewage is 0.05 mg/l. Waste liquor and residue from chlor-alkali industry, instrument manufacturing, paint, battery production, military industry and other industries are sources of mercury pollution in water and soil. There are many methods for the determination of mercury, including cold atomic absorption spectrometry, cold atomic fluorescence spectrometry and dithizone spectrophotometry.

The principle of copper dithizone spectrophotometric determination of mercury is to digest water samples with potassium permanganate and potassium persulfate in acidic medium at 95 C, and convert inorganic mercury and organic mercury into divalent mercury. Reduction of excess oxidizer millimeters with hydroxylamine hydrochloride. Under acidic conditions, mercury ion forms an

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orange chelate with dithizone. Redundant dithizone was extracted with organic solvent and washed with alkali solution for millimetres. Absorption was measured at 485 nanometer wavelength. The content of mercury in water samples was determined by standard curve method. Millimeter dithizone spectrophotometry is suitable for the determination of polluted surface water, domestic sewage and industrial wastewater. Taking 250 ml water sample, the minimum detection concentration of mercury is 2 ug/l, and the upper limit of determination can reach 40 ug/l.

3. Determination of cadmium

Cadmium is not an essential element of the human body. Cadmium is toxic. It can accumulate in the liver, kidney, bone and other parts of the body. It has an impact on human health, and even endangers life, such as the world-famous painful disease events. When the cadmium content in water is 0.1 mg/l, the surface water's self-purification ability will be slightly inhibited. The safe cadmium concentration of silver carp is 0.014 mg/l, and the cadmium content of irrigation water is 0.04 mg/l, which will cause obvious pollution to soil and rice. When the cadmium content in irrigation water is 0.007 mg/l, it will cause pollution. The pot capacity of most freshwater is less than 1 microgram/liter, and the average concentration of cadmium in seawater is 0.15 microgram/liter. The main pollution sources of cadmium are electroplating, mining, smelting, dyestuff, battery and chemical wastewater. The determination methods of cadmium include inductively coupled plasma atomic emission spectrometry (ICP-AES), atomic absorption spectrometry, dithizone spectrophotometry, anodic stripping voltammetry and oscillopolarography.

Principle of Spectrophotometric Determination of cadmium with dithizone: In strong alkali solution, cadmium ion and dithizone form red complex. After extraction and separation with trichloromethane, the content of cadmium in water samples was determined by 518 nanometer wavelength spectrophotometry. When the light path is 20 mm and the sample volume is 100 ml, the minimum detection concentration of cadmium is 0.001 mg/l, and the maximum detection limit is 0.06 mg/l. This method is suitable for the determination of cadmium in natural water and wastewater polluted by cadmium.

4. Determination of chromium

Chromium is one of the essential trace elements in organisms. The toxicity of chromium is closely related to its valence state. There are two valence states of chromium in water: trivalent state and hexavalent state. Trivalent chromium can participate in normal sugar metabolism, but the toxicity of hexavalent chromium is 100 times that of trivalent chromium, which is easily absorbed and accumulated by human body. High chromium concentration can cause headache, nausea, vomiting, diarrhea, bloody stool and other symptoms, as well as carcinogenic effect. When the concentration of trivalent chromium in water is I mg/l, the turbidity of water increases obviously. When the concentration of hexavalent chromium in water is 1 mg/l, the water is light yellow and has a wet taste. Trivalent chromium and hexavalent chromium in water can be converted to each other under certain conditions. Natural water does not contain chromium. The average concentration of chromium in seawater is 0.05 microgram/liter. The average concentration of chromium in drinking water is low. The main pollution sources of chromium are chromium ore processing wastewater, tannery wastewater, electroplating wastewater and printing and dyeing wastewater. The determination methods of chromium include inductively coupled plasma atomic emission spectrometry (ICP-AES), atomic absorption spectrometry, diphenylcarbazide spectrophotometry, ammonium ferrous sulfate titration, polarography, gas chromatography and chemiluminescence.

Principle of determination of total chromium by ammonium ferrous sulfate titration: In acidic medium, trivalent chromium is oxidized to hexavalent chromium by ammonium persulfate with silver salt as catalyst, boiled with a small amount of sodium chloride, and determined by excessive ammonium persulfate titration. The chlorine gas produced in the reaction was removed, phenyl was used instead of o-aminobenzoic acid as indicator and ammonium ferrous sulfate as standard. The solution was titrated to bright green. According to the concentration of ammonium ferrous sulfate standard solution and the titration blank, the total chromium content in water sample was calculated.

5. Determination of arsenic

Arsenic is a non-essential element of human body. The toxicity of elemental arsenic is very small, but all arsenic compounds have strong toxicity. Trivalent arsenic compounds are more toxic than other arsenic compounds. Oral arsenic trioxide (commonly known as arsenic) 5-10 mg can cause acute poisoning, lethal dose is 60-200 mg. The content of arsenic in surface water varies greatly with different water sources and geographical conditions. Natural water usually contains a certain amount of arsenic. The arsenic content of freshwater is 0.2-230 micrograms/liter, that of seawater is 6-30 micrograms/liter, that of some major rivers in China is 0.01-0.6 micrograms/liter, that of the Yangtze River is generally lower than 6 micrograms/liter, that of the Songhua River is 0.3-1.17 micrograms/liter, and that of the Yangtze River is 0.3-1.17 micrograms/liter. Mining, metallurgy, chemical industry, chemical pharmacy, textile, glass, leather and other industries. The determination methods of arsenic include inductively coupled plasma atomic emission spectrometry (ICP-AES), atomic fluorescence spectrometry, new silver salt spectrophotometry, diethylaminodithiocarbonate spectrophotometry and atomic absorption spectrometry.

After digestion, thiourea was added to the water sample and arsenic was reduced to trivalent arsenic. When potassium borohydride solution is added in acidic medium, arsenic trivalent forms hydrogen arsenide gas, which is directly introduced into quartz tube atomizer by carrier gas (argon). Then it is atomized in an argon-hydrogen flame. Ground state atoms are excited by a special hollow cathode light source to generate atomic fluorescence. By measuring the relative intensity of atomic fluorescence, the content of arsenic in the sample solution was calculated by using strong fluorescence in direct proportion to the content of arsenic in the solution.

6. Determination of lead

Lead is a toxic heavy metal that can be accumulated in human, animal and plant tissues. The main side effects are anemia, nervous system diseases and kidney damage. When rice and wheat were irrigated with water containing 0.1-4.4 mg/l of lead, the lead content in crops increased significantly. The world's fresh water lead content is 0.06-120 micrograms/liter, the median is 3 micrograms/liter; the sea water lead content is 0.03-13 micrograms/liter, the median is 0.03 micrograms/liter; the main pollution sources of lead are wastewater such as batteries, smelting, hardware, machinery, coatings, electroplating and other industries. The determination methods of lead include inductively coupled plasma atomic emission spectrometry, atomic absorption spectrometry, dithizone spectrophotometry, anodic stripping voltammetry and oscillopolarography. The principle of determination of lead by inductively coupled plasma atomic emission spectrometry is the same as that of cadmium. Principle of lead determination by Dithizone spectrophotometry: In reducing medium of ammoniacal citrate-cyanide with pH of 8.5-9.5, lead and dithizone form a light red lead dithizone integrator which can be extracted by methane trioxide or carbon tetrachloride, and lead content in water sample can be obtained by standard curve method at 510 nanometers. When the sample is extracted with 10 ml dithizone trichloromethane solution, the minimum detection concentration of lead is 0.01 mg/l and the upper limit is 0.3 mg/l. The method is suitable for the determination of trace lead in surface water and wastewater.

7. Determination of zinc

Zinc is a necessary and beneficial element for human body. When the concentration of zinc in alkaline water exceeds 5 mg/l, the water has a bitter taste and is milky white. When the content of zinc in water is 1 mg/L, it has a slight inhibition on the biological oxidation process of water body and a slight toxicity to aquatic organisms. The main pollution sources of zinc are wastewater from electroplating, metallurgy, pigments and chemical industries. The determination methods of zinc include inductively coupled plasma atomic emission spectrometry, atomic absorption spectrometry, dithizone spectrophotometry, anodic stripping voltammetry and oscillopolarography. The determination of zinc by atomic absorption spectrometry has high sensitivity and little interference. It is suitable for the determination of zinc in various water. If there is no atomic absorption spectrophotometer, dithizone spectrophotometry, anodic stripping voltammetry or oscillopolarography can be used. The principle of dithizone spectrophotometric determination of zinc: in acetic acid buffer medium of pH 4.0-5.5, zinc ion and dithizone form a red integrator, which is extracted by trichloromethane or carbon tetrachloride, and the absorbance is determined at 535 nanometer maximum absorption wavelength. The content of zinc in water sample was determined by standard curve method. When the sample volume is 100 ml and the optical path is 10 mm colorimetric dish, the minimum detection concentration of zinc is 0.005 mg/l, and the upper limit of determination is 0.3 mg/l. It is suitable for the determination of zinc in natural water and slightly polluted groundwater.

8. Determination of copper

Copper is a necessary element for human body. Adults need about 20 mg of copper every day, but excessive intake of copper is still harmful to human body. The copper content in drinking water largely depends on the type of water pipe and tap, which may be as high as 1 mg/l, indicating that the amount of copper intake through drinking water may be considerable. Copper is very toxic to organisms, and its toxicity is related to its morphology. Usually, the concentration of copper in freshwater is about 3 micrograms per liter and that in seawater is about 0.25 micrograms per liter. The main pollution sources of copper are wastewater from electroplating, smelting, hardware, petrochemical and chemical industries. The determination methods of copper include inductively coupled plasma atomic emission spectrometry, atomic absorption spectrometry, sodium diethy laminodithiocarbamate extraction spectrophotometry, new cuprous extraction spectrophotometry, anodic stripping voltammetry and oscillopolarography.

The extraction spectrophotometric principle of the new cuprous bromide is to reduce divalent copper ions to cuprous bromide ions by hydroxylamine hydrochloride. In neutral or weak acidic solutions, the reaction of cuprous bromide with new cuprous bromide produces a yellow complex with a molar ratio of 1:2. Complexes were extracted with trichloromethane-methanol mixed solvent. Absorption was measured at 457 nanometers and standard substances were used. Quantitative analysis of copper in water samples was carried out by quasi-curve method. The minimum detection concentration of copper in extraction spectrophotometry is 0.06 mg/l and the upper limit is 3 mg/l. It is suitable for the determination of copper in surface water, domestic sewage and industrial wastewater.

9. Determination of other metal compounds

According to the types of water and wastewater pollution and different requirements for water quality, sometimes other metal elements need to be monitored. Common monitoring methods for other metal compounds are shown in Table 1. Detailed information can be consulted in “Water and Wastewater Monitoring and Analysis Method” and other water quality monitoring data.

Table 1 Common Monitoring Methods for Other Metal Compounds

element	Harm	Analysis method	Determination of Concentration Range
iron	With low toxicity and high industrial water content, macula is formed on the product.	1. Atomic Absorption Spectrometry 2. Phenanthroline Spectrophotometry 3. EDTA Titration	0.03-5.0 mg/l 0.03-5.00 mg/l 5-20 mg/l
Slow	With low toxicity and high industrial water content, the product will be	1. Atomic absorption 2. Potassium periodate	0.01-3.0 mg/l minimum 0.05 mg/l 0.01-4.0 mg/l

	stained.	oxidation spectrophotometry 3. Formaldehyde bladder Spectrophotometry	
calcium	Human essential elements, but too high can cause gastrointestinal discomfort, scaling	1. EDTA Titration 2. Atomic Absorption Spectrometry	2 ^ 100 mg/l 0.02-5.0 mg/l
magnesium	Human essential elements, excessive catharsis and diuresis, scaling	1. EDTA Titration 2. Atomic Absorption Spectrometry	2-100 mg/l 0.002-5.0 mg/l
plating	Elements and their compounds are extremely toxic.	1. Graphite Furnace Atomic Absorption Spectrophotometry 2. Activated Carbon Adsorption-Cyanine S Spectrophotometry	0.04-4 mg/l minimum 0.1 mg/l
Inlay	It is carcinogenic and harmful to aquatic organisms. Line salt can cause allergic dermatitis.	1. Atomic Absorption Spectrometry 2. Butanedione Spectrophotometry 3. Oscillopolarography	0.01-8 mg/l 0.1-4 mg/l minimum 0.06 mg/l

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