Research on environmental management of domestic waste incineration fly ash and high salt water discharge into the sea

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Abstract:

In our comprehensive management proposal for fly ash washing wastewater discharge into the sea, we establish stringent control measures across four categories: general elements, nutrients, heavy metals, and organic pollutants. Our approach is rooted in respect for and compliance with national and international pollution control standards. We define the acceptable parameters for pH, salinity, and the content of Chemical Oxygen Demand (COD), suspended solids, total nitrogen, ammonia nitrogen, phosphates, various heavy metals, and organic pollutants. Our plan includes thoroughly treating wastewater, emphasizing the removal of lead, desalination, effective precipitation, and filtering processes before the wastewater is discharged into the sea. We advocate for constant surveillance and stringent management practices to maintain a healthy marine ecosystem. Moreover, we acknowledge the need for additional biological testing in actual work to more scientifically and comprehensively understand the potential impact of the discharged wastewater on marine ecology. Our overall goal is to ensure that the potential environmental effects of fly ash washing wastewater are minimized while adhering to the highest environmental management standards.

Keywords: Fly Ash Washing, Wastewater Discharge, Pollutant Control, Wastewater Treatment, Marine Ecology, Environmental Management.

1 Introduction

Domestic waste incineration fly ash (from now on referred to as fly ash) is the residue collected from the flue gas purification system of the waste incineration plant. According to the "China Statistical Yearbook 2019", the number of waste incineration plants in 2018 was 331, and the incineration capacity was about 100 million tons, an increase of nearly three times compared with 2010 in less than ten years. Accounting for 45% of the total[1]. Washing is an important way for the utilization and disposal of fly ash. The washing process produces a large amount of high-salt wastewater, which produces waste salt after multi-effect evaporation. Waste salt is usually disposed of by landfill at present. Still, the landfill site has limited land resources and a small disposal capacity, which makes it difficult and expensive to dispose of waste salt. Because waste salt is easily soluble in water, it is corrosive to a certain extent[2]. Soil and groundwater pollution may be caused by leaching, and the potential environmental risks are extremely high.

Therefore, the new national landfill standards have increasingly stringent requirements for salt control, and the landfill disposal of waste salt will be greatly limited in the future. In addition, the salt products formed after waste salt purification have fewer consumption methods, low utilization value, and small market demand. Compared with sea salt and mineral salt, product competitiveness is weak[3]. The current waste salt purification and utilization methods cannot meet the huge waste salt disposal. Market disposal needs.

On the other hand, the ocean has a large capacity and high salinity. It can theoretically accommodate a large amount of potassium chloride, sodium chloride, calcium chloride, and other substances. It is an excellent carrier for waste salt. Therefore, high-salt wastewater is discharged into the sea after safe treatment. It will be a relatively long-lasting and feasible disposal method. This article will provide a technical basis for high-salt water discharge through brine analysis after washing wastewater[4].

2. Fly ash samples and washing process

The sources of the fly ash of domestic waste incineration in this project are five domestic waste incineration power plants in a certain city, all of which use grate furnaces. The source of fly ash from hazardous waste incineration is Jiaxing Hazardous Waste Disposal Center, which uses a rotary kiln incinerator[5]. Five samples of domestic waste incineration fly ash from different sources, and one sample of hazardous waste incineration fly ash were collected for detection. The test results are as follows.

2.1 Fly ash sample detection

2.1.1 Acidity (pH)

The test showed that the pH of the five domestic waste incineration fly ash samples submitted for inspection was between 9.3 and 12.6 (reserved to one decimal place), which was strongly alkaline. The pH of a sample of hazardous waste incineration fly ash submitted for inspection was 11.9, which was also strongly alkaline. The test results are detailed in Table 3-1.

Table 2-1 pH test results of fly ash samples

Indicator	Unit	Detection limit	Nanhu	Haiyan	Jiashan	Haining	Pinghu	Hazardous waste
pH	Dimensionless	/	9.31	12.29	12.4	12.19	12.55	11.92

2.1.2 Heavy metals

(1) Content of toxic substances

No heavy metal beryllium was detected in the five domestic waste incineration fly ash samples submitted for inspection, and hexavalent chromium was not detected in the Nanhu and sea salt samples. Among the five samples, zinc and lead contents are relatively high, between 1330-8100mg/Kg and 1490-4490mg/Kg, respectively. The content is between 46.9~616.0mg/Kg, 12.4~69.5mg/Kg, 87.5~338.0mg/Kg, 6.0~32.1mg/Kg, 142~386mg/Kg, 3.1~22.1mg/Kg, 0.7~13.8mg/Kg Kg, 42.2~126.0mg/Kg, 27.9~75.6mg/Kg. The hexavalent chromium content in samples from Jiashan, Haining, and Pinghu ranged from 3.29 to 57.7mg/Kg. Silver and manganese were not detected in one sample of hazardous waste incineration fly ash submitted for inspection. The contents of chromium, zinc, lead, nickel, cadmium, manganese, cobalt, mercury, arsenic, and antimony were 264mg/Kg, 9.12×10^4mg/ Kg, 1.60×10^4mg/Kg, 166mg/Kg, 21.1mg/Kg, 340mg/Kg, 1.26×10^3mg/Kg, 17.0mg/Kg, 63.8mg/Kg, 64.0mg/Kg. The test results are shown in Table 2-7.

From the test results, it can be seen that the content of zinc and lead in the fly ash samples of domestic waste incineration is relatively high, and the content of cobalt in the fly ash of hazardous waste incineration is also relatively high. The contents of other heavy metals in the six samples were relatively low, and the detection results were relatively close.

Table 2-2 Detection results of heavy metal content in fly ash samples

Indicator	Unit	Detection limit	Nanhu	Haiyan	Jiashan	Haining	Pinghu	Hazardous waste
Chromium	mg/Kg	0.5	46.9	65.5	616	309	142	264
Zinc	mg/Kg	1.2	5.88×10^3	5.34×10^3	7.21×10^3	8.1×10^3	1.33×10^3	9.12×10^4
Lead	mg/Kg	1.4	2.06×10^3	1.49×10^3	3.67×10^3	1.82×10^3	4.49×10^3	1.60×10^4
Nickel	mg/Kg	0.4	12.4	17.1	69.5	27.5	52.0	166
Cadmium	mg/Kg	0.1	178	87.5	267	154	338	21.1
Beryllium	mg/Kg	0.04	ND	ND	ND	ND	ND	ND
Silver	mg/Kg	0.1	6.0	6.5	6.0	13.1	32.1	ND
Manganese	mg/Kg	3.1	190	142	386	221	296	340
Cobalt	mg/Kg	0.5	3.1	4.8	22.1	6.7	11.7	1.26×10^3
Hexavalent chromium	mg/Kg	2	ND	ND	57.7	19.3	3.29	26.6
HG	mg/Kg	0.002	8.28	6.47	15.1	0.658	13.8	17.0
Arsenic	mg/Kg	0.010	43.6	42.2	42.8	121.0	126.0	63.8
Antimony	mg/Kg	0.010	424	112	335	774	838	64

Note: ND means not detected.

(2) Leaching toxicity

Nickel and beryllium were not detected in the leaching solution of the five household waste incineration fly ash samples submitted for inspection; cadmium, silver, and hexavalent chromium were not detected in samples from Haiyan, Jiashan, Haining, and Pinghu; lead was not detected in Nanhu samples; No cyanide was detected in Haining samples. The detection rates of zinc, chromium, fluoride, arsenic, and mercury in the leaching solutions of the five samples were 100%, and the detection concentrations were 9.31~12.55mg/L, 0.09~0.54mg/L, 2.78~5.98mg/L, 0.001~0.004mg/L, 0.0007~0.0041mg/L; lead was detected in 4 samples, the detection rate was 80%, and the detection concentration was between 32.6~79.5mg/L; 3 samples were detected cyanide, the detection rate is 60%, and the detection concentration is between 0.028~0.097mg/L; cadmium, silver, and hexavalent chromium are only detected in Nanhu samples, the detection rate is 20%, and the detection concentration is 3.18 , 022, 0.066mg/L.

Nickel, cadmium, beryllium, silver, hexavalent chromium, and cyanide were not detected in the leaching solution of a sample of hazardous waste incineration fly ash submitted for inspection. The concentrations of zinc, lead, chromium, arsenic, mercury, and fluoride were 1.56mg /L, 57.6mg/L, 0.08mg/L, 0.003mg/L, 0.09mg/L and 4.34mg/L, the test results are shown in Table 2-8.

It can be seen from the test results that the concentrations of heavy metals, fluoride, and cyanide in the leachate sample are not high.

Table 2-3 Test results of leaching toxicity of fly ash samples

Indicator	Unit	Detection limit	Nanhu	Haiyan	Jiashan	Haining	Pinghu	Hazardous waste
Zinc	mg/L	0.01	0.59	7.70	2.46	2.80	1.88	1.56
Lead	mg/L	0.03	ND	33.8	79.5	32.6	60.0	57.6
Nickel	mg/L	0.02	ND	ND	ND	ND	ND	ND
Chromium	mg/L	0.02	0.10	0.09	0.54	0.10	0.11	0.08
Cadmium	mg/L	0.01	3.18	ND	ND	ND	ND	ND
Beryllium	mg/L	0.004	ND	ND	ND	ND	ND	ND
Silver	mg/L	0.01	0.22	ND	ND	ND	ND	ND
Hexavalent chromium	mg/L	0.004	0.066	ND	ND	ND	ND	ND
Fluoride	mg/L	0.0148	3.33	4.34	5.98	4.72	2.78	4.34
Cyanide (cyanide ion)	mg/L	0.005	ND	0.096	0.097	ND	0.028	ND
Arsenic	mg/L	0.00010	0.00122	0.00259	0.00071	0.00067	0.00409	0.00340
HG	mg/L	0.00002	0.00410	0.00086	0.00176	0.00077	0.00068	0.0908

Note: ND means not detected.

2.1.3 Organic matter

No VOCs or SVOCs were detected in the five domestic waste incineration fly ash samples submitted for inspection. In a sample of hazardous waste incineration fly ash submitted for inspection, the detected contents of naphthalene, 2-methylnaphthalene, benzene, and toluene were 0.40mg/Kg, 0.32mg/Kg, 1.2mg/Kg, and 2.5mg/Kg respectively. The test results are shown in Table 2-4.

Table 2-4 Detection results of organic content in fly ash of hazardous waste incineration (partial)

	Indicator	Unit	Detection limit	Content
Hazardous Waste Incineration Fly Ash	Naphthalene	mg/kg	0.05	0.40
	2-Methylnaphthalene	mg/kg	0.06	0.32
	Benzene	mg/kg	1.0	1.2
	Toluene	mg/kg	1.0	2.5

The test results showed that the content of dioxins in 5 pieces of domestic waste incineration fly ash was between 130 and 2600ng-TEQ/Kg. The content of dioxins in hazardous waste incineration fly ash is 180ng-TEQ/Kg.

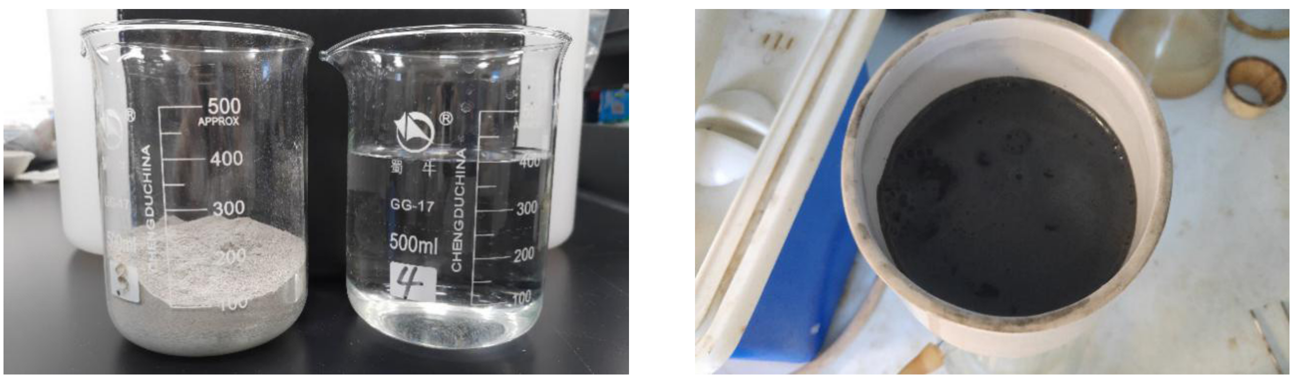
Table 3-5 lists the test results.

Table 2-5 Test results of dioxins in incinerated fly ash samples

Sample	Unit	Nanhu	Jiashan	Pinghu	Haining	Haiyan	Hazardous waste
Dioxins	I-TEQ (ng/Kg)	1400	310	2600	130	310	180

2.2 Fly ash washing process

The laboratory washes the fly ash in the third stage to obtain the washing wastewater. The specific steps are as follows: take 100g of the fly ash incinerated from domestic waste, and add 400mL of reverse osmosis concentrated water according to the water-cement ratio of 4:1 in the first stage of washing. Use an electric constant speed agitator to wash with water for 30 minutes while stirring at a rate of 150r/min; First-level washing filter cake, second-level washing according to the ratio of water-cement ratio 3:1, add 300 mL of reverse osmosis concentrated water, and wash with water for 30 minutes while stirring, and the rest of the conditions are the same; repeat the second step to obtain the second-level washing filter cake; Take the secondary water-washed filter cake, and the third-level water-washed filter cake according to the water-cement ratio of 3:1, wash with water for 30 minutes while stirring, and the rest of the conditions are the same; repeat the second step to obtain the third-level water-washed filter cake and the mixed filtrate after three times of water washing, The filter cake was dried in an oven at 105°C for 24 hours, and the moisture content was measured to be about 35%.



Water-cement ratio 1:4 for primary washing

Get primary washing wastewater

Figure 3-1 Primary water washing

Five parts of the wastewater from different sources of incineration fly ash washing and one part of wastewater from hazardous waste incineration fly ash washing were tested, and the results are as follows.

2.2.1 Wastewater pH (pH)

The pH of the 5 domestic waste incineration fly ash washing wastewater samples submitted for inspection was between 8.6 and 12.5 (reserved to one decimal place). Except for the Nanhu sample, the remaining samples were strongly alkaline; the 1 hazardous waste incineration sample was submitted for inspection. The pH of the fly ash washing wastewater sample was 12.3, which was strongly alkaline, similar to that of domestic waste incineration fly ash. The test results are shown in Table 2-6.

Table 2-6 pH test results of waste incineration fly ash and washing wastewater

Index	Unit	Nanhu	Haiyan	Jiashan	Haining	Pinghu	Hazardous waste
pH	dimensionless	8.58	12.4	12.47	12.32	12.47	12.3

2.2.2 Heavy metals in wastewater

The test results showed that the detection rate of total mercury, total arsenic, total nickel, total chromium, total silver, and total lead in 5 samples of domestic waste incineration fly ash and water washing wastewater was 100%, and the detection concentrations were between 0.54

and 18.3 μg /L, 0.4~4.6μg/L, 10.3~34.7μg/L, 34.3~522μg/L, 1.95~614μg/L, 312~6.33×104μg/L; total cadmium was not detected only in Haining samples, and The detection rate was 80%, and the detection concentration was between 1.28~1.26×104μg/L; the total beryllium was not detected.

In one sample of hazardous waste incineration fly ash and washing wastewater submitted for inspection, total beryllium was not detected. The contents of total mercury, total arsenic, total nickel, total chromium, total silver, total cadmium, and total lead were 5.36 μg/L, 0.4 μg/L, 10.4 μg/L, 57.6 μg/L, 7.76 μg/L, 4.14 μg/L and 1.24 μg/L. The test results are shown in Table 3-7.

From the test results, it can be seen that the concentration of total lead in the wastewater incinerated with fly ash and washing water is generally high, the concentration of total cadmium in the Nanhu sample is high, and the concentration of other heavy metals is generally low. The concentrations of heavy metals in hazardous wastewater washing wastewater samples were generally low. Except for total cadmium and total lead, the concentrations of other heavy metals were the same as those in domestic waste incineration fly ash washing wastewater.

Table 2-7 Detection results of heavy metals in fly ash washing wastewater

Indicator	Unit	Detection limit	Nanhu	Haiyan	Jiashan	Haining	Pinghu	Hazardous waste	Standard*
Total mercury	μg/L	0.04	18.3	1.80	3.77	4.8	0.54	5.36	1
Total arsenic	μg/L	0.3	0.6	4.6	1.7	0.8	0.4	0.4	100
Total beryllium	μg/L	0.04	ND	ND	ND	ND	ND	ND	2
Total Nickel	μg/L	0.06	20.2	34.7	34.7	33.7	10.3	10.4	50
Total chromium	μg/L	0.11	85.4	87.2	522	73.5	34.3	57.6	100
Total silver	μg/L	0.04	614	15.1	6.94	185	1.95	7.76	100
Total Cadmium	μg/L	0.05	1.26×10^4	1.28	5.18	ND	3.77	4.14	10
Total lead	μg/L	0.09	312	6.33×10^4	1.06×10^5	5.62×10^4	3.76×10^4	1.24	100

**Note:* Table 2 and Table 3 of "Pollutant Discharge Standards for Urban Sewage Treatment Plants" (GB18918-2002).

In addition, the project team tested two washing wastewater samples, and the test results showed that no hexavalent chromium was detected in the two samples; the concentrations of total zinc were 80 and 18 μg/L, and the concentrations of total chromium were 11 and 18 μg/L respectively. The concentrations of total cadmium were 1.6 and 0.1 μg/L, the concentrations of total copper were 36 and 26 μg/L, and the concentrations of alkylmercury were 0.004 and 0.041 μg/L (reserved to three decimal places). The concentrations of alkylmercury in 2 samples and total chromium in 1 sample were slightly higher than the discharge standard, and the rest of the heavy metals did not exceed the standard. The test results are shown in Table 3-8.

Table 2-8 Main heavy metal water quality indicators of project ash washing wastewater (unit: μg/L)

Pollutants	Wastewater from this project		Pollutant Discharge Standards for Urban Sewage Treatment Plants GB18918-2002
	Washing wastewater 1	Washing wastewater 2	
Total zinc	80	18	1000
Total chromium	11	104	100
Hexavalent chromium	ND	ND	50

Total Cadmium	1.6	0.1	10
Total copper	36	26	500
Alkylmercury	0.00425	0.041	Not allowed to check out

2.2.3 Wastewater dioxins

Since the dioxins are mainly concentrated on the fly ash particles, most of the dioxins still exist in the solid phase during the washing process of the fly ash. Table 2-9 shows the changes in the concentration of dioxins in the washing wastewater from continuous sampling of this project's washing fly ash process. The dioxin content in the produced ash washing wastewater is 0.15~1.1 pg-TEQ/L, which is lower than the Japanese sea discharge standard (10 pg-TEQ/L) and "Drinking Water Hygienic Standard" (GB5749-2006) requirements (30 pg-TEQ/L).

Table 2-9 Detection concentration of dioxins in a continuous sampling of washing wastewater (unit: pg-TEQ/L)

Detection unit	Sampling number						Japan Sea Discharge Standard	Hygienic Standards for Drinking Water GB5749-2006
	1	2	3	4	5	6		
SGS-CSTS Standard Technical Services (Shanghai) Co., Ltd. (SGS)	1.1	0.15	0.19	0.26	0.15	0.18	10	30
Chinese Academy of Sciences	-	2.1	3.3	-	-	-		

2.2.4 Other indicators

According to the sewage discharge standard and the characteristics of washing wastewater, three indicators of suspended solids (SS), cyanide, and fluoride were selected for further detection and analysis. The test results are shown in Table 3-10.

In the five domestic waste incineration fly ash washing wastewater samples submitted for inspection, cyanide was not detected, and the concentrations of SS and fluoride were between 166-184 mg/L and 0.79-3.17 mg/L, respectively. Cyanide was not detected in one part of hazardous waste incineration fly ash and washing wastewater submitted for inspection, and the concentrations of suspended solids and fluoride were 7mg/L and 6.16mg/L, respectively.

Table 2-10 Test results of other pollutants

Index	Unit	Detection limit	Nanhu wastewater	Haiyan wastewater	Jiashan wastewater	Haining wastewater	Pinghu wastewater	Hazardous wastewater
Suspended matter	mg/L	4	166	176	171	168	184	7
Fluoride (fluoride ion)	mg/L	0.006	2.21	0.788	1.03	3.17	1.64	6.16
Cyanide	mg/L	0.004	ND	ND	ND	ND	ND	ND

3. Analysis of indicators of fly ash washing wastewater discharged into the sea

3.1 acidity and alkalinity (pH)

The pH value of the fly ash washing wastewater of this project is 8.5~12.47. The pH value of seawater is in the range of 7.8~8.3, and its value changes very little. The pH value in this range is conducive to the growth and reproduction of marine organisms. The long-term stability of seawater pH depends on the buffering effect of carbon dioxide-carbon balance. Under certain conditions of temperature, pressure, and salinity, when seawater receives a large amount of acidic or alkaline substances, the original carbon dioxide buffer system may be broken, resulting in a dramatic change in seawater pH, which may cause most planktonic Plants to die, the marine life chain was broken, and the oxygen content in the atmosphere decreased sharply, which affected the flora and fauna of the entire ecosystem. Therefore, the pH value of fly ash washing wastewater discharged into the sea is one of the important control indicators.

3.2 Heavy metals

Heavy metals in the ocean generally enter the human body through eating seafood. Mercury (methylmercury) causes Minamata disease (see Minamata Bay Mercury Pollution Incident); cadmium, lead, chromium, etc., can also cause body poisoning or cause cancer and teratogenicity, which will cause harm. The degree of harm of heavy metals to organisms is generally mercury>lead>cadmium>zinc>copper; organic mercury>inorganic mercury, hexavalent chromium>trivalent chromium, and the seedlings and larvae of general marine organisms are more sensitive to heavy metal pollution than adults, so once heavy metal pollution occurs in the sea, it may have a serious impact on the ecosystem of the entire coastal waters.

The test results of two washing wastewater samples by the project team showed that no hexavalent chromium was detected in the two samples, the concentrations of total zinc were 80 and 18 μg/L, the concentrations of total chromium were 11 and 104 μg/L, and the concentrations of total cadmium were The concentrations were 1.6 and 0.1 μg/L, the total copper concentrations were 36 and 26 μg/L, and the alkylmercury concentrations were 0.004 and 0.041 μg/L (three decimal places). The concentrations of alkylmercury in 2 samples and total chromium in 1 sample were slightly higher than the discharge standard, and the rest of the heavy metals did not exceed the standard. The test results are shown in Table 3-1.

Table 3-1 Main heavy metal water quality indicators of project ash washing wastewater (unit: μg/L)

Pollutants	Wastewater from this project		Pollutant Discharge Standards for Urban Sewage Treatment Plants GB18918-2002
	Washing wastewater 1	Washing wastewater 2	
Total zinc	80	18	1000
Total chromium	11	104	100
Hexavalent Chromium	ND	ND	50
Total Cadmium	1.6	0.1	10
Total Copper	36	26	500
Alkylmercury	0.00425	0.041	Not allowed to check out

After the heavy metals enter the washing wastewater in the form of chlorides during the washing process of fly ash, the leaching characteristics mainly depend on the washing process and the pH value of the washing solution. Studies have shown that the leaching amount of heavy metals increases with the increase of the liquid-solid ratio. Still, since the residual heavy metal oxidation state and matrix state (residue) in the fly ash will not enter the wastewater, the heavy metal's leaching amount will be stable after reaching the peak. According to domestic sewage discharge management requirements, the concentration of heavy metals discharged into the sea from fly ash washing wastewater can be controlled according to the relevant technical standard limits.

3.3 Salinity

Salinity is one of the most important ecological factors in the marine environment. Every organism must have suitable growth salinity requirements. When the environmental salinity exceeds this range, the growth, development, reproduction, behavior, and distribution of organisms will be affected. According to research, most marine invertebrates and some cartilaginous fishes are isotonic animals, and the salt content of their blood and body fluids is similar to that of seawater. In contrast, the blood salt content of variable osmotic animals (such as bony fishes) is only 30~50% of the saline content of ambient seawater. The process of osmosis occurs when the salinity of the environment changes. Therefore, when the salinity of the environment rises suddenly, the cells of marine organisms without an osmotic adjustment mechanism may produce plasmolysis, resulting in metabolic disorders or even death. Therefore, the discharge of industrial wastewater must ensure that its salinity should be equivalent to the environmental background value to reduce its ecological environment damage.

The fly ash washing process must consume a large amount of Na_2CO_3 to remove insoluble Ca^{2+} and Mg^{2+} ions in the wastewater. Due to the introduction of a large amount of Na salt and the high chlorine content of the wastewater, the salt content in the fly ash washing wastewater can reach about 20%, and direct discharge can cause a sharp increase in the salinity of local waters. Therefore, if the fly ash washing wastewater is discharged into the sea, the impact of its salinity on the marine ecological environment must be considered.

3.4 Chemical Oxygen Demand (COD)

COD is an indicator of the amount of reducing substances in water. The greater the chemical oxygen demand, the more seriously the water body is polluted by organic matter. After the fly ash washing process, the residual organic matter in the wastewater will be reduced to the greatest extent. Theoretically speaking, the chemical oxygen demand (COD) content in the fly ash is very low. The five domestic waste incineration fly ash samples submitted for inspection showed that neither VOCs nor SVOCs were detected, which also illustrates this point. However, in the actual operation process, to avoid the incomplete decomposition or reverse generation of organic matter caused by the possible incineration temperature not reaching the standard or insufficient local oxygen content, it is necessary to use COD as a control index for the sea fly ash washing wastewater. At the same time, there are also. It is necessary to implement the relevant management and control requirements for the total discharge of COD into the sea in the national pollutant discharge permit management system.

3.5 Dioxins

Dioxin is the abbreviation of Dioxins, persistent organic pollutants, including polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). 210 compounds. Because dioxins are highly toxic, refractory, bioaccumulative, and chemically stable, they can be transported in the environment for a long distance, posing a serious threat to human health and the environment. It has been confirmed that they can be enriched in the biological chain, so they are Listed as the first batch of controlled substances under the Stockholm Convention on Persistent Organic Pollutants. Generally speaking, dioxins have significant toxicity and endocrine-disrupting effects and have many negative effects on organisms, including destroying the immune system and enzyme disorders.

The detection of dioxins in ash washing wastewater showed that the content was 0.15~1.1 pg-TEQ/L, which was lower than the Japanese sea discharge standard (10 pg-TEQ/L) and the "Drinking Water Hygienic Standard" (GB5749-2006) requirements (30 pg-TEQ/L). Relevant studies have shown that during the washing process of fly ash, the dioxin concentration and I-TEQ (toxic equivalent) characteristics in fly ash do not change before and after washing. This is because dioxins are water-insoluble organic substances, and their content in fly ash is also at trace levels, so overall, the washing process has a weak effect on its dissolution. However, considering the high risk of dioxins, Therefore, if the fly ash washing wastewater is discharged into the sea, to control its impact on the marine ecological environment, it is also necessary to control its dioxin content.

3.6 Suspended matter

The diameter of suspended solid particles is between 0.1-910um, including water-insoluble inorganic matter, organic matter, mud sand, clay, microorganisms, etc., which are the main reasons for water turbidity. During the washing process of fly ash, some particles with smaller particle sizes enter into the wastewater, which is difficult to settle naturally and is usually suspended in water. Excessive suspended matter content in seawater will make the water turbid, hinder the convection of surface water and deep water, cause silting of the water body in the near-shore sea area, affect the appearance of the water body, reduce the transparency of the water, and hinder the diffusion of dissolved oxygen to the lower part of the water body, interfering with The respiration and metabolism of aquatic organisms lead to suffocation and death of fish and accelerate the deterioration of water bodies. Therefore, the content of suspended solids in water is one of the indicators to measure the degree of water pollution, and the monitoring of suspended solids in wastewater plays an important role in indicating the status of water quality and water pollution. The test results of suspended solids in fly ash washing showed that the concentration was between 166~184mg/L. Due to the small particle size of suspended solids and high surface adsorption potential energy, it is easy to adsorb dioxins, heavy metals, and other insoluble pollutants on it. Therefore, the suspended solids content should also be discharged as fly ash washing wastewater. One of the sea control requirements.

3.7 Nutrients (N, P)

In the near-shore marine environment, although nutrients such as N and P in seawater are indispensable components for the reproduction and growth of marine organisms, and are the basis of marine primary productivity and food chains, if the behavior of nutrients entering the ocean is not controlled, random Promoting a large number of nutrients such as nitrogen and phosphorus to enter the water body will cause red tide, which will block the gas exchange and energy exchange on the water surface, resulting in the death of fish, shrimp, crab, and shellfish in large numbers, causing great damage to aquatic resources. Interfere with the construction of harbor channel basins. To prevent the occurrence of red tide disasters, it is a crucial environmental protection measure to prevent and control the large amount of nutrients such as nitrogen and phosphorus entering the water body.

The nitrogen and phosphorus elements in the fly ash washing process mainly enter the washing wastewater through soluble nitrate nitrogen and ammonia nitrogen. In contrast, the components of nitrite nitrogen and phosphorus are relatively low. Relevant studies have shown that the mass fraction of ammonia nitrogen (calculated as N) in washing wastewater is the highest (>67%). From the process of this project, the anions in the fly ash washing solution are mainly Cl-, SO42-, CO32-, and the anion contents of P and N are relatively low. Ensure that the concentration of ammonia nitrogen in wastewater can meet the relevant discharge standards. Nevertheless, considering that nutrients entering the sea have a certain impact on the ecological environment of coastal waters and considering the requirements of the national pollutant discharge permit management system, it is still necessary to discharge nutrients (ammonia nitrogen, total nitrogen, and total phosphorus) as fly ash washing wastewater. Sea control indicators.

4. Pollution control strategy of fly ash washing wastewater discharged into the sea

Based on the pollution production link of the fly ash washing process and the analysis results of the characteristic pollutants of this project, preliminary construction of the fly ash washing wastewater discharge pollutant control index system includes four categories: general elements, nutrient salts, heavy metals, and organic pollutants, a total of 17 indicators, see Figure 4-1 for details. In addition, considering that the washing wastewater of this project is finally merged into the industrial sewage treatment plant and then discharged into the sea, the content of other pollutants not included in the index system of this research should meet the control requirements for the export of the sewage treatment plant, that is, the “Urban Sewage Treatment Plant Pollutants Level 1 A emission limits in Emission Standards[6].

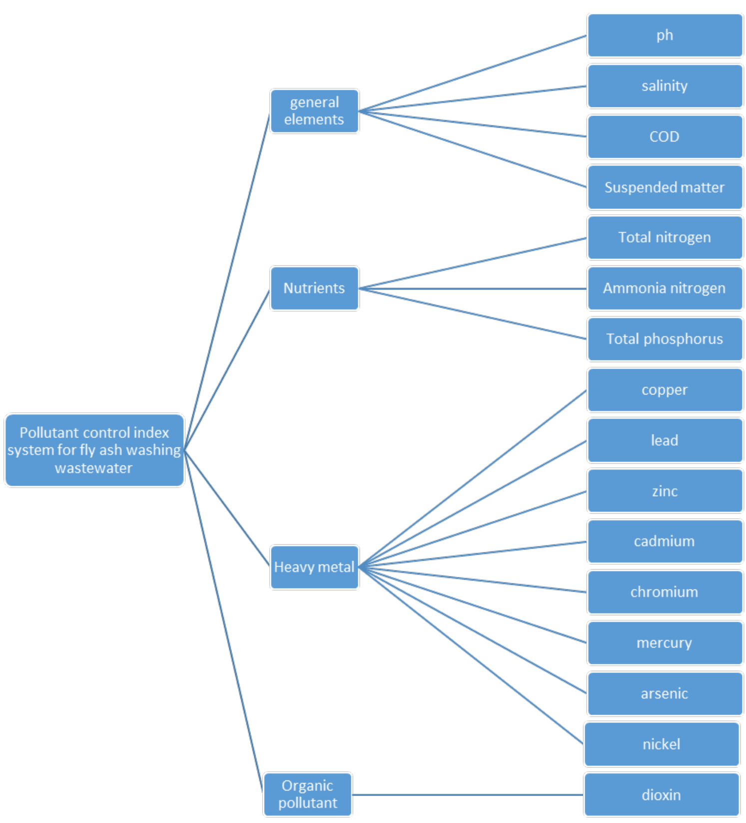


Figure 6-2 Evaluation index system of pollutants discharged into the sea from washing wastewater

4.1 General elements

4.1.1 pH

According to "Pollution Control Standards for Sewage Marine Disposal Projects" (GB 18486-2001), "Comprehensive Wastewater Discharge Standards" (GB 8978-1996), "Pollutant Discharge Standards for Urban Sewage Treatment Plants" (GB 18918-2002) and other national sewage For discharge requirements, it is initially recommended that the pH control requirements for fly ash washing wastewater discharged into the sea be 6.0~9.0.

4.1.2 Salinity

Combined with the actual control requirements of sewage outfalls, the salinity control requirements for fly ash washing wastewater discharged into the sea are initially put forward; that is, the salinity should be roughly equivalent to the salinity of the near-shore marine environment, and the salinity difference should not be higher than 5‰ of the background.

4.1.3 CODs

Considering the fact that the fly ash washing wastewater of this project is finally merged into the industrial sewage treatment plant and discharged into the sea, it is initially suggested that the COD control requirement for the fly ash washing wastewater discharged into the sea is 50 mg/L.

4.1.4 Suspended matter

Considering the relevant control requirements at home and abroad and in the United States, it is initially recommended that the suspended solids control requirement for fly ash washing wastewater discharged into the sea is 10 mg/L.

4.2 Nutrients

4.2.1 Total nitrogen and ammonia nitrogen (calculated as N)

In view of the fact that the content of this project is more compatible with the scope of use of the urban sewage treatment standard, and the standard has relatively strict requirements on the concentration limit of total nitrogen discharge, for this reason, it is initially recommended that the total nitrogen control requirement for fly ash washing wastewater discharged into the sea is 15 mg/L .

For ammonia nitrogen, considering the requirements of relevant domestic and EU standards, it is initially recommended that the ammonia nitrogen control requirement for fly ash washing wastewater discharged into the sea is 5mg/L.

Phosphate (as P). Considering the requirements of relevant domestic and EU standards, it is initially recommended that the phosphate (calculated as P) control requirement for fly ash washing wastewater discharged into the sea is 0.5mg/L.

4.3 Heavy metals

After a comprehensive analysis of domestic and other countries' sewage discharge requirements, it is initially suggested that the control requirements for various heavy metal elements in fly ash washing wastewater discharged into the sea are as follows:

—— Copper, 0.5mg/L.
——Lead, 0.1mg/L.
——Zinc, 1.0mg/L.
——Cadmium, 0.01mg/L.
——Mercury, 0.001mg/L.
——Arsenic, 0.1mg/L.
——Chromium, 0.1mg/L.
——Nickel, 0.05mg/L.

4.4 Organic Pollutants

In order to reduce the impact of washing wastewater on the marine ecological environment after being discharged into the sea, it is initially suggested that the dioxin control requirements for fly ash washing wastewater discharged into the sea should refer to the Japanese sewage discharge standard that is, 10.0 pg-TEQ/L.

In the previous analysis of characteristic pollutants, traces of naphthalene, 2-methylnaphthalene, benzene, and toluene were detected in the fly ash of hazardous waste incineration. Therefore, these four organic pollutants are only selected as control items. The recommended control requirements are as follows:

——Naphthalene, 0.1mg/L
——2-Methylnaphthalene, 0.1mg/L
——Benzene, 0.1mg/L
——Toluene, 0.1mg/L

4.5 Outlet Control Requirements

Considering that the washing wastewater of this project contains a relatively high concentration of heavy metals, it is recommended that the concentration of heavy metals of class I should be controlled within the t-level A limit standard before the wastewater enters the biochemical pool. In addition, since dioxins are mainly concentrated in SS in fly ash washing wastewater, and the biochemical treatment process of wastewater has a great influence on the concentration of SS, it is recommended to control the concentration of SS within 10mg/L before entering the heavy metal removal tank[7].

In general, based on the analysis results of the pollution production link and the main characteristic pollutants of the fly ash washing process, combined with the relevant technical standards and management regulations at home and abroad, preliminary construction of the fly ash washing wastewater discharge pollutant index system, including General elements, nutrient salts, heavy metals, and organic pollutants are classified into four categories, and corresponding suggestions on the requirements for pollutant discharge control limits are put forward. However, considering that the content of this research is relatively advanced, there may be some pollution factors that have not been considered[8]. Therefore, it is recommended to consider further biological testing of fly ash washing wastewater in the actual work process so as to understand and evaluate fly ash more scientifically and comprehensively. The impact of gray washing wastewater discharged into the sea on the marine ecological environment, and then formulate supervision and management measures.

5 Disposal conclusion of fly ash washing wastewater to be discharged into the sea

5.1 Control indicators for wastewater discharge into the sea

Preliminary construction of the fly ash washing wastewater discharge pollutant index system includes four categories of general elements, nutrients, heavy metals, and organic pollutants and correspondingly puts forward recommendations for pollutant discharge control limit values.

5.2 Fly ash washing treatment technology

Fly ash washing wastewater enters the adjustment tank for lead removal pretreatment and is mixed with low-concentration wastewater; after mixing, the washing wastewater is pumped to the secondary sedimentation tank and final sedimentation tank through anoxic and aerobic tanks for desalination treatment and effective precipitation; after sedimentation, the wastewater After being filtered through the filter cloth device, it enters the discharge pool. After being inspected to meet the requirements of relevant technical standards, it is planned to be connected with the sea discharge pipeline of the industrial sewage treatment plant and discharged into the sea through a high-level well.

5.3 Environmental Management

Pay attention to the ecological impact of the outlet location on sensitive targets such as ecological red lines, fishing grounds, and salt fields, and propose technical conditions for setting waste salt discharge outlets based on background salinity, ocean currents, and diffusion conditions. It is recommended to consider further biological testing of fly ash washing wastewater in the actual work process so as to more scientifically and comprehensively understand and evaluate the impact of fly ash washing wastewater discharged into the sea on the marine ecological environment and then standardize) control standards, and industrial sewage plant tailwater. After the combined management, the salinity meets the technical requirement of 5‰ (relative to the sea area).

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