Discharge Limits of Development and Utilization of Effluents from NORM Industries

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Introduction

- In China, there are more than 10 industries related to development and utilization of NORM, including rare earth, niobium, tantalum, zirconium and coal industries.
- Only rare earth industry has its own emission standards, meaning that other industries should implement the limits of gross alpha and beta which is stipulated by the general national standard related to effluent discharge.

- There are four national or industrial standards related to effluent of uranium mining and NORM industries

- Integrated waste water discharge standard（GB8978-1996）

Concentration of gross α and β in wastewater are less than 1Bq/L and 10Bq/L, respectively.

It is also stipulated that gross alpha and beta are a kind of pollution factors, which need to meet the discharge standards at the discharge outlet of the treatment workshop.

- This standard is too strict to be implemented for NORM industry.

- **Regulation for Radiation protection for uranium processing and fuel fabrication facilities（EJ1056-2005）**

Concentration limit of uranium at the waste liquid treatment outlet is 0.1 mg/L, and that at the total industrial waste water outlet is 0.05 mg/L.

- **Emission standard of pollutants for rare earths industry（GB26451-2011）**

Total amount of uranium and thorium in wastewater should not exceed 0.1 mg/L, and the total amount of uranium and thorium in waste gas should not exceed 0.1 mg/m^3.

- **Regulations for radiation protection and radiation environment protection in uranium mining and milling (GB23727)**

Radioactive materials or RNs	Unit	Discharge Limits
$U_{Natural}$	mg/L	0.3
^{226}Ra	Bq/L	1.1
^{210}Po	Bq/L	0.5
^{210}Pb	Bq/L	0.5

Measures for Environmental Radiation Monitoring and Information Disclosure of Enterprises Related to Exploitation and Utilization in NORM Industries which was issued in 2018:

- **Enterprises need to carry out environmental radiation monitoring on their own**
- **Discharge shall be immediately stopped, analyzing the reasons and reporting to the provincial ecological environment authority, if concentration of the effluent exceeds the limits**

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Discharge limits for airborne effluents

- The main airborne effluents produced by the development and utilization of associated radioactive ores are radon, thoron, uranium and thorium discharged with dust.
- Because radon and thoron can not be handled, and most of them are discharged in fugitive way, discharge limits for radon and thoron are not suitable to be set.
- Uranium and thorium are emitted into the air accompany with dust passes through the chimney, which are mainly reduced by removing dust.

Industries	Particulates Discharge Limits（mg/m^3）	Concentration of U & Th in Particulates	Max. Discharge Con. of U & Th（mg/m^3）
Rare earth mining and selection	50	U：0.05%, Th:0.05%	U：0.025，Th:0.025
RE Smelting	40	U：0.1%，Th:0.1%	U：0.04，Th:0.04
Monazite	40	U：0.6%，Th:5%	U：0.24，Th:2
Zircon sand	30	U：0.1%，Th:0.1%	U：0.03，Th:0.03
Coal power generation	30	U：0.05%, Th:0.05%	U：0.015，Th:0.015
Coal smelting	100	U：0.05%, Th:0.05%	U：0.05，Th:0.05
Niobium and tantalum	30	U：1%，Th:1%	U：3，Th:3
Vanadium	100	U：0.05%, Th:0.05%	U：0.05，Th:0.05

- **Discharge limits of uranium and thorium in airborne effluents from development and utilization of NORM industries can be calculated theoretically, based on concentration of particulate matter and the grade of uranium and thorium.**
- **It is proposed that the discharge limits of uranium and thorium from gaseous effluent should be no more than 0.1 mg/m^3.**
- **But, special industries should be considered in a particular way, i.e. monazite grinding process.**

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Concentration of radioactive wastewater in typical NORM industries:

- Wastewater from Rare Earth Separation Plant（^{238}U：16.8Bq/L；^{232}Th：2.57Bq/L；^{226}Ra：2.49Bq/L）
- Radioactive Wastewater from a Nb-Ta Smelter：

Samples	U（mg/L）	^{226}Ra（Bq/L）	Th（mg/L）	α（Bq/L）	β（Bq/L）
Extraction residue	8.95	6.94	2.78	42.03	90.82
Slag washing wastewater	0.89	7.16	2.97	54.95	67.64
Refined organic residue (aqueous phase)	0.84	6.09	1.48	25.24	48.80

Zirconium oxychloride wastewater （Bq/L）：

Sample	Results		
	^{238}U	^{226}Ra	^{232}Th
Wastewater 1	5.1	7.0×10^{-1}	4.7×10^{-1}
Wastewater 2	9.5×10^{-1}	1.0×10^{2}	3.6×10
Wastewater 3（liquor extraction）	3.44×10^{3}	1.81×10^{3}	1.23×10^{3}
Wastewater treated by sewage station	3.8	1.1	6.2×10^{-1}

Common Treatment Methods of Radioactive Wastewater:

Ion Exchange Method

- Usually uranium in waste water can be treated to less than 0.1-0.3 mg/L, which is often used for uranium treatment in uranium mining and metallurgical wastewater.
- The disadvantage is that it is not suitable for the development and utilization of radioactive wastewater associated with complex solutions.

Precipitation method

- At present, it is the main method for the development and utilization of associated radioactive minerals to remove radioactive wastewater.
- Uranium and thorium are removed by neutralization precipitation and radium is treated by barium sulfate coprecipitation.
- This method is suitable for complex radioactive wastewater with high decontamination coefficient, 70-90% uranium removal, 80-90% radium removal by barium sulfate coprecipitation . It is a classical method for radium removal from aqueous solution.

Reverse Osmosis Method:

- It has been widely used in uranium mining and milling and in the development and utilization of NORM industries in China.
- It is mainly used for desalting and eliminating nuclides in radioactive wastewater.
- The desalination rate is over 90%.

Distillation Method

- Retaining radionuclides in residual liquor by distillation and concentration, it has the advantage by using multi-stage combination, the decontamination coefficient up to 10^5-10^6.
- The disadvantage is high energy consumption.
- The wastewater from the development and utilization of associated radionuclides has a large amount of water and high salinity.
- This method is not suitable for the treatment of radioactive wastewater from the development and utilization of NORM industries.

Absorption Method

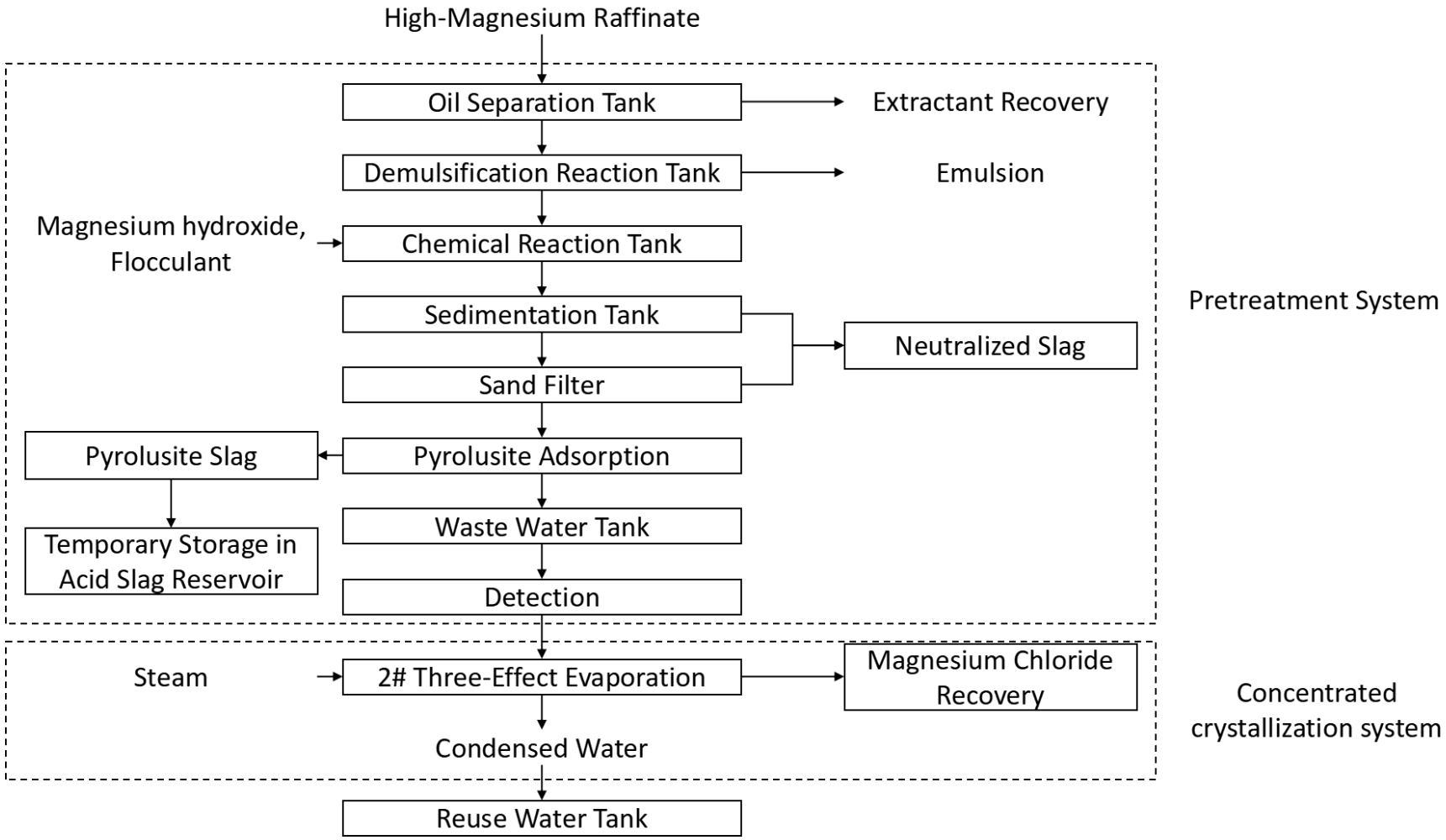
Radioactive substances (including other heavy metals) in water can be removed by adsorbing porous solid substances or fibrous substances

Decontamination ratio is as high as 10-1000 times.

It has been applied to the treatment of radioactive wastewater from the development and utilization of associated radioactive minerals.

Typical adsorbents and adsorption coefficients

Adsorbent	Absorption Coefficient
Kaolinite	4.5~6.2
Vermiculite	3.3~4.3
Pyrolusite	8
Zeolite	62~68


High-Magnesium Raffinate
Oil Separation Tank
Extractant Recovery
Demulsification Reaction Tank
Emulsion
Magnesium hydroxide, Flocculant
Chemical Reaction Tank
Sedimentation Tank
Neutralized Slag
Sand Filter
Pyrolusite Slag
Pyrolusite Adsorption
Waste Water Tank
Temporary Storage in Acid Slag Reservoir
Detection
Pretreatment System
Steam
2# Three-Effect Evaporation
Magnesium Chloride Recovery
Condensed Water
Concentrated crystallization system
Reuse Water Tank

Principles for Determining Discharge Limits in Wastewater

- Considering the treatment technology of radioactive waste water, the control level of radioactive pollutants, and the degree of damage of radioactive pollutants
- Considering cost-benefit analysis, taking into account operability and certain forward-looking

Principles for Determining Discharge Limits in Wastewater

- Refer to the relevant emission standards at home and abroad, which are equivalent or stricter than those countries, and consistent with domestic similar standards;
- Considering the diversity and complexity of the development and utilization of NORM industries

■ **Control Items in wasterwater**

U, Th and ^{226}Ra,

■ **Discharge Limits**

Concentrations of U and Th in wastewater are not more than 0.3mg/L, ^{226}Ra is not more than 1.1Bq/L

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Questions to be discussed:

- Are there effluent discharge limits for the NORM industries in your country? If so, how to identify these values?
- What's the relationship between NORM industries and uranium mining when identifying these limits?
- How to consider the radiation exposure situation for workers in the NORM industries, i.e. public exposure or occupational exposure?

Questions to be discussed:

- **Is there a radionuclide limit standard for soil management when dealing with NORM industrially contaminated sites? If so, which nuclides? What is the limit?**

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Thank you for our attention