

# CURRENT SITUATION OF MUNICIPAL SLUDGE PRODUCTION AND DISPOSAL IN GUANGXI

Muxi Zhang<sup>1,2,3</sup>, Xiaojie Sun<sup>1,2,3\*</sup>

1. Guangxi Key Laboratory of Environmental Pollution Control Theory and Technology, Guilin University of Technology, Guilin 541004, China

2. Guangxi Collaborative Innovation Center for Water Pollution Control and Water Safety in Karst Area, Guilin University of Technology, Guilin 541004, China

3. Guangxi Key Laboratory of Environmental Pollution Control Theory and Technology for Science and Education Combined with Science and Technology Innovation Base, Guilin University of Technology, Guilin 541004, China

**Abstract:** With the acceleration of urbanization in China, the sewage treatment capacity and scale continue to rise, and the production of municipal sludge is also more and more. This paper summarizes and analyzes the current situation of sludge generation and disposal in Guangxi region and each city in 2019, and puts forward suggestions for sludge disposal in Guangxi region, which is of great significance for planning the future development of municipal sludge in Guangxi region. Taking into account factors such as area, carbon emission, sludge composition and calorific value in Guangxi region, the sludge in Guangxi region is suitable for disposal by anaerobic digestion + land use and aerobic fermentation + land use; when the sludge is not suitable for land use and incineration and building materials utilization conditions are not available locally, landfill disposal will be considered. In the long run, Guangxi sludge should be disposed in a multi-form and multi-channel way.

## INTRODUCTION

Along with the speeding up of industrialization and urbanization and the tightening of environmental policy, urban sewage treatment capacity has been improved rapidly and the scale of sewage treatment has surged in recent years<sup>[1]</sup>. In 2019, there were 2,471 sewage treatment plants in China, with a total sewage treatment volume of 53.7 billion m<sup>3</sup> and a sewage treatment capacity of 180 million m<sup>3</sup>/d<sup>[2]</sup>. With the improvement of sewage treatment capacity, sludge as a by-product of sewage treatment continues to increase. According to the calculation of 5 ~8 t per 10,000 m<sup>3</sup> domestic sewage production (in moisture content 80%)<sup>[3]</sup>, the annual output of sludge in our country is more than 40 million t, with an annual growth rate of 10%, is expected to break through 60 million t (in moisture content 80%) in 2020 to 2025<sup>[4]</sup>. According to the 2020 Urban and Rural Construction Statistical Yearbook, the output of dry

sludge from municipal sewage treatment plants at the prefecture level and above in 2020 is 1.163×10<sup>7</sup> t, and the dry sludge yield of county-level cities is 1.7×10<sup>6</sup> t. Based on the wet sludge with 80% moisture content, the wet sludge yield in counties and above cities is 6.664×10<sup>7</sup> t<sup>[5]</sup>.

Sewage sludge is a semi-solid waste produced from wastewater treatment plants (WWTPs) after a series of physical, chemical and biological wastewater treatment. Sludge is a heterogeneous complex mixture, mainly composed of fibers, animal and plant residues, microorganisms, pathogens, parasites and heavy metals. If the sludge is not properly treated and disposed of, it may cause serious secondary environmental pollution problems<sup>[6-10]</sup>. According to the 13th Five-Year Plan, the disposal of sludge generated by sewage treatment will be one of the main directions of environmental protection and pollution control in China in the future, so it can be seen that the disposal of sludge will be elevated to a new

historical height <sup>[11]</sup>. In the 14th Five-Year Plan for Urban Sewage Treatment and resource Utilization, it is pointed out that sludge treatment facilities should be included in the construction plan of local sewage treatment facilities, requiring that the harmless disposal rate of urban sludge should reach more than 90% by 2025, and the harmless disposal of sludge should be fully realized by 2035 <sup>[5]</sup>. Although 90% of sewage treatment plants in China have realized sludge dewatering and reduction treatment, the proportion of sewage treatment plants that realize biological stabilization treatment of sludge is less than 3%. Most of the sludge is directly landfill without stabilization treatment, and less than 20% of the sludge has been safely treated and disposed of <sup>[12]</sup>. Therefore, further efforts are needed to meet the requirements of the program.

Sludge disposal is an important link in sewage treatment process<sup>[13]</sup>. However, there is a serious phenomenon of "heavy water and light mud" in the construction of sewage treatment plants, and the lack of subsequent supporting treatment facilities leads to a large amount of sludge backlog, which has not been reasonably and safely treated and disposed of, and has brought a lot of impacts on the normal operation of sewage treatment plants <sup>[14,15]</sup>. The sludge from Nanning sewage treatment plant is concentrated and dehydrated to 80% water content and then transported to an agricultural compound fertilizer company to make biological compound fertilizer. However, fertilizer companies cannot guarantee long-term and stable acceptance of sludge due to seasonal and sales conditions. As a result, sludge accumulates inside the treatment plant, increasing the environmental safety risk around the plant and affecting the normal operation of each sewage treatment plant <sup>[16]</sup>. Therefore, how to properly and safely dispose the sludge with huge output and complex composition, so as to reduce, harmlessly and recycle it, has become an urgent environmental problem to be solved in Guangxi.

This paper summarizes and analyzes the current situation and disposal of sludge in Guangxi region and cities in 2019, and further analyzes the harmless disposal

method of sludge in Guangxi. It is necessary to fully understand the current situation of sludge generation and disposal in Guangxi region, provide decision-making reference and policy measures for relevant departments, and plan the future development of municipal sludge in Guangxi region.

### SLUDGE PRODUCTION STATUS

According to the data released by the Ministry of Housing and Urban-Rural Development, there were 56 sewage treatment plants in Guangxi in 2019, with a total sewage treatment volume of 126.72 million m<sup>3</sup> and a sewage treatment capacity of 3.918 million m<sup>3</sup>/d<sup>[5]</sup>. Guangxi dry sludge production capacity of 120,000 t, dry sludge treatment capacity of 90,000 t, the treatment rate is only 75.51%. Figure 1 shows the dry sludge production volume of urban sewage treatment plants in Guangxi in 2019. Nanning, Liuzhou and Guilin were the major cities with sludge production volume exceeding 10,000 t/a, with a total sludge production volume of 92,000 t, accounting for 74.1% of the total production volume in the whole region.

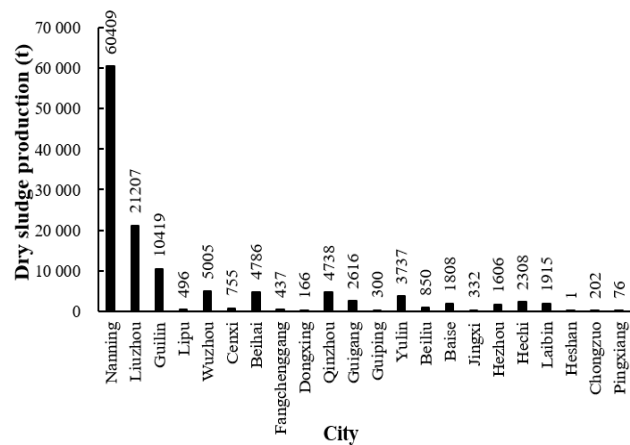


Figure 1 Dry sludge production of Guangxi Municipal Sewage Treatment Plant in 2019

### CURRENT SITUATION OF SLUDGE DISPOSAL

At present, the main sludge disposal methods are sanitary landfill, incineration, building materials utilization and land utilization <sup>[17]</sup>. In terms of final destination, landfill is still the main destination of urban sludge in our country at present. The second is land use and building materials use <sup>[18]</sup>. More than 52.89% of the sludge generated by sewage treatment plants in China is treated and disposed in the way of sanitary landfill, and 14.97% is land utilized <sup>[1]</sup>. During the 13th Five-Year Plan period, the capacity of harmless treatment and disposal facilities for sludge (measured by wet sludge with 80% moisture content) was 60,100 tons per day nationwide, and Guangxi reached 1,921 tons per day. Among them, Guangxi has 1,622 tons/day for cities, 122 tons/day for counties and 177 tons/day for towns <sup>[19]</sup>. The proportion of municipal sludge land utilization in Guangxi reached 54.2%, landfill 27.8%, incineration 2%, and others 16% <sup>[13]</sup>. Harmless sludge disposal facilities in the region are mainly concentrated in Nanning, Liuzhou and other major cities, Guilin, Beihai, Guigang, Hezhou, Hexi and Laibin are mainly landfill, Wuzhou, Qinzhou and other parts of the sludge landfill disposal method, a considerable number of cities have not been equipped with harmless disposal facilities <sup>[20]</sup>.

## Landfill

Sludge landfill can be divided into two ways: single landfill and mixed landfill with municipal solid waste. However, the addition of household garbage and sludge will significantly increase the concentration of total suspended solids in the leachate and the proportion of particles with large particle size in the filtrate, which will accelerate the physical blockage process of the drainage system at the bottom of the landfill. Therefore, from the perspective of blockage of the drainage system, it is extremely unfavorable to mix sludge with municipal solid waste for landfill <sup>[21]</sup>. Landfill has the advantages of simple operation, large processing capacity, low investment and remarkable effect <sup>[22]</sup>. However, landfill will occupy a large amount of land, resulting in a waste of resources, and also cause a large amount of

greenhouse gas emissions, which is not conducive to the realization of carbon neutrality goals <sup>[23,24]</sup>. It costs a lot in seepage prevention and leakage prevention, and it needs to be equipped with the treatment of leachate and waste gas in the later stage <sup>[25]</sup>. More mountains and less land are the main characteristics of land resources in Guangxi. The area of mountains, hills and stone mountains accounts for 69.7% of the total area, and there are no landfill sites that can sustainably accept sludge. Therefore, landfill is not suitable for long-term as the main sludge disposal method in Guangxi.

## Land utilization

Sludge land utilization is an effective disposal method that can realize the recycling of sludge resources. Land use of sludge includes agricultural use, green space use, forest use and land restoration. Sludge contains a large amount of nitrogen, phosphorus, organic matter and other nutrients, so the application of sludge can increase soil nutrients, promote plant growth, and provide favorable conditions for sludge land use. Guangxi encourages sludge products that meet standards and have controllable risks to be used for land use, especially for forestland, land improvement and landscaping <sup>[26]</sup>. When the sludge meets the requirements of "Sludge for Landscaping in sludge Disposal of Urban Sewage treatment Plant" (GB/T23486-2009), it can be used in the construction and maintenance process of urban green space system or suburban forest land. It is generally used as cultivation medium soil, soil improvement material, and can also be used as raw material for making organic fertilizer. When the mud conforms to the provisions of "Mud for Land Improvement of Sludge Disposal in Urban Sewage Treatment Plant" (GB/T 24600-2009), it can be used for soil improvement in saline-alkali land, desertified land and abandoned mining site <sup>[27]</sup>.

Yang Jianlao<sup>[28]</sup> to Guangxi District towns and disposal of the sludge characteristics in the direction of research shows that Guangxi towns of total nitrogen, phosphorus and potassium content in sludge, within the

range 4.19% ~ 13.62% higher than that of agricultural and forest land use and landscape with the nutrient requirements of three kinds of argillaceous standards, especially the passengers, the total nitrogen, phosphorus and potassium content of Guilin, the sludge is high (> 10%), Therefore, the reclamation potential of sludge land use in Guangxi area is very large. Cd is the main contributor to the potential ecological risk of heavy metals in urban sludge in Guangxi, and there are potential ecological risks in the sludge for agricultural use<sup>[29]</sup>. However, Xue Wanlai et al.<sup>[30]</sup> studied the impact of sludge land use on soil ecological environment, and showed that short-term land use of sludge did not significantly increase soil heavy metal content, which was safe for soil ecological environment. Huang Xingfa et al.<sup>[31]</sup> showed that the heavy metal content of sludge in Nanning met the standard requirements of landscaping, land improvement and national and Guangxi local agricultural A-grade sludge, and sludge could be used for landscaping, soil improvement, forestland and agriculture. The organic matter and total nutrient content of sewage sludge in Guilin city are high, and the heavy metal content is low. All pollutant control indexes can meet the agricultural characteristics of various soil properties. From the perspective of technical and economic analysis, the sewage sludge in Guilin city should be selected for land use<sup>[32]</sup>. However, limited to relevant national standards, sludge cannot be directly used for land.

At present, the basic building of adjust measures to local conditions, variety, and the argillaceous feature matching dispose and resource utilization of sludge treatment technology system, has formed four mainstream dispose and resource utilization of sludge safe disposal technology route: anaerobic digestion + land use, aerobic fermentation + land use, dry incineration + ash landfill or building materials utilization, deep dehydration + emergency landfill<sup>[33]</sup>. According to the characteristics of sludge in Guangxi, the methods of anaerobic digestion + land use and aerobic fermentation + land use are suitable for Guangxi.

## **Building materials using**

The construction material utilization of sludge is mainly to make bricks by mixing sludge with inorganic materials such as fly ash or waste clay after deep dehydration, or to use cement kiln exhaust gas to dry sludge and then add raw material for clinker calcination<sup>[34]</sup>. The building materials utilization of sludge has the forms of making bricks, making cement, making light aggregate and making biochemical fiberboard. The product of sludge building materials utilization is a material product that can be used in construction projects, so it does not need to rely on land as the carrier of its final consumption, and can also replace part of the raw materials used to manufacture building materials<sup>[35]</sup>. Sludge preparation of ceramsite is conducive to reducing the leaching amount of heavy metals in raw materials, and the leaching level of heavy metals does not exceed the safety standard limit<sup>[36]</sup>, which can be safely used in engineering construction and water treatment fields. Sludge brick solidify heavy metals in sludge, which is safe and feasible. Zhang Yu et al.<sup>[37]</sup> determined through leaching experiment that the amount of harmful heavy metals dissolved from sludge brick is very low, and it can be used as external wall material without causing harm to environmental safety.

The utilization of sludge building materials can effectively reduce energy consumption and solve the problem of sludge stacking occupying land resources, which is conducive to promoting the virtuous cycle of economic development, but also effectively reducing environmental pollution and realizing ecological sustainable development. It has good economic, social and environmental benefits<sup>[38]</sup>. The ash content of sludge in Guangxi is 56.46%, more than twice that of 27.18% of coal, and the inorganic mineral components in the ash can be used in the production of building materials, which indicates that the utilization value of sludge is very high<sup>[39]</sup>. Liuzhou also has large cement production enterprises in Lionan District, which can use existing facilities for sludge disposal according to local conditions<sup>[40]</sup>. Therefore, Guangxi should actively study

the use of sludge to make building materials in order to achieve the purpose of resource recovery.

### Incineration

Incineration technology can reduce a large amount of sludge and effectively convert it into energy <sup>[41]</sup>. Sludge incineration process mainly includes semi-dry incineration and mixed combustion power generation <sup>[42]</sup>. Sludge incineration gasifies water, mineralizes sludge, kills pathogens, and minimizes sludge volume <sup>[43]</sup>. Sludge incineration is to treat itself by using its own calorific value, which reflects the concept of energy recycling and sustainable development. In view of the advantages of sludge incineration reduction and harmless treatment, it is likely to become the mainstream process of sludge treatment <sup>[44]</sup>. However, sludge drying incineration is faced with the problems of high energy consumption and high operating cost, which limits its promotion and application in Guangxi <sup>[45]</sup>.

In addition to the reduction and capacity reduction of sludge mixed firing power generation, the steam generated can also be used for power generation, and the flue gas can be basically discharged up to standard. The ash and slag after mixed firing can be used as cement clinker or raw material for brick making to realize the resource utilization of sludge <sup>[42]</sup>. However, at the same sludge to coal blending mass ratio, with the decrease of sludge energy quality, the calorific value of mixed fuel per unit mass decreases, and the power generation decreases, and more coal energy needs to be consumed for sludge drying, thus reducing the power generation efficiency. The elemental composition of sludge in Guangxi is quite different from that of coal. For example, the C content is 20.648%, which is only one third of the coal, and the estimated calorific value of sludge is 7 423.34 kJ/kg, which is only one third of the coal <sup>[39]</sup>. There is no comprehensive and systematic study on the control of carbon emission and pollutant emission by incineration. In general, Guangxi does not have the conditions to carry out extensive incineration disposal.

### SUGGEST

Sludge treatment and disposal technology should first achieve harmlessness, and then consider the maximum degree of resource utilization. In the Technical Specification for Land Use of Sludge Products of Guangxi Urban Sewage Treatment Plant, it is required to strictly control the concentration of toxic and harmful substances such as heavy metals and organic pollution of sludge products, and prohibit the sludge without harmless treatment to be directly absorbed in the land by mixing with soil or covering soil and other simple ways, so as to prevent secondary pollution. Land use is also prohibited for the sludge products that fail to meet the standard after harmless treatment of toxic and harmful sludge products and fail to reach the sludge stabilization and harmless technology.

With the promotion of carbon neutrality, future sludge treatment and disposal should aim at energy saving and consumption reduction and energy resource recovery. The energy conversion technology of sludge is mainly based on the existence of organic components in sludge. The average content of organic matter and total nutrients in sludge of major cities in Guangxi is 34.63% and 87.11 g/kg, which has high agricultural value. The total land area of Guangxi is 237,600 square kilometers, accounting for 2.5% of the total land area of China, and the cultivated land area reaches 4,385,900 hectares (the number of land use change surveys in 2018). At the end of 2016, the per capita cultivated land is about 0.08 hectares (1.20 mu). Conditions for sludge land use. Therefore, under the premise of controlling the risk of heavy metals, land use of treated sludge is a sludge disposal technology in line with the current situation in Guangxi. When the sludge is not suitable for land use and the local incineration and building materials utilization conditions are not available, landfill disposal can be adopted.

The sludge disposal process consumes energy on the one hand and emits a large amount of greenhouse gases on the other hand. Typically, 400 to 600 kg CO<sub>2</sub>

equivalent direct carbon emissions can be generated per ton of wet sludge. The carbon emission level of other typical disposal schemes is lower than that of direct sludge landfill. It is estimated that landfill can emit 500 kg CO<sub>2</sub> equivalent GHG per ton of wet sludge, while incineration has direct CO<sub>2</sub> emissions of 74 kg and indirect CO<sub>2</sub> emissions of 119 kg per ton of wet sludge, and land use increases carbon emissions in the short term. However, in the long run, soil carbon sinks can be increased by increasing plant carbon sinks and promoting CH<sub>4</sub> oxidation. Land use has the lowest carbon emissions, while sanitary landfill has a large carbon emission. Therefore, anaerobic digestion + land use and aerobic fermentation + land use can be considered as the best methods for sludge disposal, followed by sludge incineration and building materials utilization, and finally sanitary landfill.

## CONCLUSION

Sludge disposal needs to choose the appropriate disposal method according to local conditions. Based on the main characteristics of the land resources of Guangxi, there is no landfill site that can accept sludge sustainably, so landfill is not suitable for the main sludge disposal method in Guangxi for a long time. Based on the economic situation of Guangxi and the characteristics of low heating value of sludge, the incineration treatment technology with high energy consumption and high treatment cost is not suitable for promotion and application in Guangxi. The heavy metal and nutrient contents of municipal sludge in Guangxi district basically meet the requirements of land use, and the fast-growing eucalyptus, sugarcane, rice, corn and banana crops are planted in a large area in Guangxi district, so there are conditions for sludge land use. Therefore, under the premise of controlling the risk of heavy metals, land use of sludge is a sludge disposal technology in line with the current situation in Guangxi. Taking into account factors such as area, carbon emission, sludge composition and calorific value in Guangxi region, the sludge in Guangxi region is suitable for disposal by

anaerobic digestion + land use and aerobic fermentation + land use; when the sludge is not suitable for land use and incineration and building materials utilization conditions are not available locally, landfill disposal will be considered. In the long run, Guangxi sludge should be disposed in a multi-form and multi-channel way.

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