Countermeasures for sludge treatment and disposal of Nanning municipal sewage treatment plant

D G Bei¹², Q Xu¹, Y Luo¹ and L Jiang¹

¹Technology Center in Guangxi Nanning Water Co., Ltd. Nanning 530031 China

E-mail: bdg6666@126.com

Abstract. This paper introduces the actual treatment and disposal of sludge from urban sewage treatment plant in Nanning, analyzes the problems and causes in the process of sludge treatment and disposal, proposes corresponding solutions, and useful thinking and suggestions.

1. Foreword
Sludge is a product of sewage treatment. For now, domestic attention to sludge treatment is far less than sewage treatment, which has led to the phenomenon of “heavy water and light mud” in the sewage treatment industry. According to statistics, in 2017, the wastewater treatment plants of the four major cities of Nanning, Liuzhou, Guilin and Wuzhou in Guangxi was about 580 million tons, and the amount of sludge with a water content of 80% was about 330,000 tons. How to properly dispose of these sludges? It is a problem that all pollution control enterprises need to pay attention to in environmental pollution control.

Technology Center in Guangxi Nanning Water Co., Ltd. Nanning (hereinafter referred to as Nanning Water), it was listed on the Shanghai Stock Exchange on June 12, 2015. In addition to being responsible for urban water supply, it is also responsible for the operation and maintenance of four sewage treatment plants in the downtown area of Nanning, namely the Jidong Wastewater Treatment Plant (300,000 t/d), Jiangnan Wastewater Treatment Plant (480,000 t/d), Wuxiang Wastewater Treatment Plant (50,000 t/d) and Santang Wastewater Treatment Plant (20,000 t/d), with a total sewage treatment capacity of 850,000t/d. More than 500 tons of sludge with a moisture content of 80% per day. Through inspection, the excess sludge mud of the Nanning municipal wastewater treatment plant is shown in table 1:

| Indicator        | Unit  | Test method | Test result |
|------------------|-------|-------------|-------------|
| Total mercury    | mg/kg | AFS         | 1.49        |
| Total chromium   | mg/kg | ICP-AES     | 45.40       |
| Total arsenic    | mg/kg | ICP-AES     | 12.38       |
| Total lead       | mg/kg | ICP-AES     | 31.07       |
| Total cadmium    | mg/kg | ICP-AES     | 2.26        |
| Total nickel     | mg/kg | ICP-AES     | 20.56       |
| Total copper     | mg/kg | ICP-AES     | 74.62       |
| Total zinc       | mg/kg | ICP-AES     | 340.56      |
| Hydrogen ion concentration | Electrode Method | 6.7       |
| Total organic matter content | % | Gravimetric method | 24%-36%    |
As can be seen from table 1, the sewage sludge of Nanning City Wastewater Treatment Plant has the characteristics of low heavy metal content, high nitrogen content, low potassium content, low organic matter content and low calorific value, but all the indicators meet the sludge treatment of urban sewage treatment plants. Agricultural mud (CJ/T309-2009 limit) Class A sludge standard requirements.

2. Sludge treatment and disposal of urban sewage treatment plant in Nanning

According to the Interim Administrative Measures of the Nanning Municipal People's Government on Sludge Treatment and Disposal of Urban Domestic Sewage Treatment Plants (Nanfu Regulation [2017] No. 27), it is clear that the sludge production unit is the main body responsible for sludge treatment and disposal, which means Greentown Water Company must ensure the discharge of sewage treatment standards and the final treatment and disposal of sludge. In accordance with the relevant national and government requirements, our company has carried out the following specific work on sludge treatment and disposal:

2.1. Treatment of sludge in sewage treatment plant

Like most sewage treatment plants, the four sewage treatment plants in the downtown area of Nanning are all dewatered with a dewatering machine, reducing sludge moisture content to 80% [1]. The flow chart is shown in figure 1:

![Figure 1. Schematic diagram of external transportation after treatment of excess sludge.](image)

2.2. Sludge single transfer

The Nanning Municipal People's Government [2017] No. 27 puts strict requirements on the transfer of joint orders. The original practice of our company is: sewage treatment plant will discharge sludge to transportation. In the tank truck of the unit, after the tank truck is full, the sludge generating unit fills in the first part of the sludge transfer joint, and then the tank truck is weighed to the designated place, and the transport unit fills in the second part of the sludge joint order, and the transport is carried out. After accepting the unit, the receiving unit fills in the third part of the joint order. After all the filling is completed, the first joint of the joint order will be kept by our company, and the second joint of the joint will be submitted by our company to the environmental protection within two days. The administrative department, the third joint shall be filed by the transport unit, the fourth joint shall be kept by the receiving unit, and the fifth unit shall be submitted to the environmental protection administrative department of the receiving place within two days from the date of receiving the hazardous waste. In May 2018, according to the Nanning Environmental Protection Bureau's Notice on Further Clarifying the Requirements for Sludge Management of Urban Domestic Sewage Treatment Plants (Southern Ring Road No. 2018 No. 384), the sludge was classified as hazardous waste, and the Wulian was no longer implemented. The single system has been changed to the triple-single system, which reduces the joint order of the environmental protection bureau where the unit is submitted and the environmental protection bureau of the receiving unit. The final receiving unit of the sludge must submit the sludge environmental management report of the previous year to the...
In March each year. 

In the whole process of sludge transfer and treatment, our current specific practices are as follows: First, the implementation of the “one car and one single system”, there must be a joint order in the transportation process, and the sludge transport enterprises are not allowed to receive no joint orders. Sludge and sludge disposal enterprises are also not allowed to receive sludge without joint orders; Second, when signing a transportation contract with the transportation unit, we have a clear route and the use of closed tanker transportation are clearly stipulated to prevent “side leakage”; Third, installation GPS positioning system and four high-definition cameras in each sludge transport vehicle to ensure that the transport vehicles are driven according to the prescribed transportation route. The GPS positioning and monitoring system platform of the sludge transport unit is also connected to the department designated by our company to implement networked joint control. For prevention problem of arbitrarily changing the transportation route during transportation, dumping, discarding, and sprinkling in the middle; Four installing high-definition video monitoring equipment at the sludge loading point of our company and the gate of the factory, the number and appearance of the sludge transportation vehicles, The transportation time is monitored in real time; The fifth is that our company regularly sends people to check the receiving accounts and transportation accounts of the sludge disposal enterprises and sludge transportation enterprises to verify the pollution. Whether the mud transportation volume and the sludge disposal amount are consistent; the sixth is to prepare an emergency plan for the occurrence of emergencies during the transportation process, and the monthly sludge production amount and sludge treatment and disposal amount data are used by the company in the Ministry of Housing and Urban-Rural Development. The urban sewage treatment management information system was truthfully reported.

2.3. Current sludge treatment and disposal methods

- The first way: building materials utilization - cement kiln co-incineration of cement.

The characteristic of Guangxi is “eight mountains, one water, one field”. The mountains are all limestone-based stone mountains, which are rich in the necessary components for the manufacture of cement, which has led to a large amount of cement production enterprise. According to statistics, the daily production capacity of cement clinker in cement production enterprises around Nanning reached 47,200 tons (only the production line with clinker production capacity of 4,000 tons/day), which facilitated the coordinated disposal of municipal sludge by cement kiln. The Guiyang Zhuang Autonomous Region Government issued the "Guiding Opinions on the Use of Cement Kilns to Dispose of Garbage Waste" in July 2014, proposing to implement the technology of co-processing waste garbage in cement kiln in the whole autonomous region, with a new dry method of 2000 tons/day or more. Relying on the cement production line, the garbage from the towns and villages around the cement plant and the sludge from the domestic sewage treatment plant will be collected and transferred to the cement plant, and the cement kiln production line will be used for incineration of waste [2]. It can be seen from table 1 that the various indexes of sludge in Nanning are in line with the requirements of GB 30760-2014 "Technical Specifications for Solid Waste Disposal of Cement Kilns", and cement can be produced by co-incineration of cement kiln.

The current practice of our company is to sign a contract with the cement production enterprise to clarify the rights and obligations of both parties. Our company is responsible for providing quantitative sludge every day. The final sludge disposal enterprise is responsible for the cement kiln co-incineration and cement production. The process flow is shown in figure 2:

Figure 2. Schematic diagram of cement kiln co-incineration cement process.

- The second way: land use - aerobic composting, products for forest land, nutrient soil and land reclamation.
China's "Sewage Treatment Plant Sludge Treatment and Pollution Prevention and Control Technology Policy (Trial)" encourages the use of sludge that meets the standards for land use; Guangxi Housing and Urban-Rural Construction Office also promulgated the "Guangxi Urban Wastewater Treatment Plant" in August 2015. Technical Specifications for Land Use of Sludge Products (DBJ/T45-003-2015), encourages the use of sludge products that meet the standard and risk control, especially for forest land, land improvement and landscaping, and stipulates local people's government Priority should be given to the procurement of sludge products and derivatives that meet the relevant land use standards of the State and Guangxi.

Nanning City is located in the subtropical zone, with an area of 100,800 mu of arable land and 16.5 million mu of forest land. In addition, there are a large number of sand land generated by mining, fast-growing and planting, and poor land in abandoned mining areas, which are obtained through aerobic composting process. Nutrient soils can be used to improve sandy land and abandoned mining areas for barren land reclamation, landscaping, woodland use, and agricultural use without food chains, such as fiber crops, tobacco, oilseeds, hemp, energy sugar cane, and flowers. It can be seen from the sludge index in table 1 that the wet mud produced by the Nanning Wastewater Treatment Plant has a water content of 80%, and its heavy metals such as mercury, chromium, cadmium, arsenic, copper, lead, zinc and nickel are not exceeded. The total content of nitrogen, phosphorus and potassium can also meet the requirements of CJ/T 309-2009 "Sludge Disposal of Agricultural Sludge in Urban Sewage Treatment Plants", which can be used for land use [3].

Our current practice of using aerobic compost for land use is to sign a contract with the manufacturer that ultimately disposes of the sludge, and at the same time clarify the rights and obligations of both parties. Our company is responsible for providing quantitative sludge daily, which is ultimately sludge. The disposal company is responsible for the aerobic composting of sludge, and the preparation of forest land, land reclamation mud and nutrient soil. The process flow is shown in figure 3:

![Figure 3. Schematic diagram of aerobic composting process.](image)

- The third way: to carry out research into the landfill fly ash area for landfill.

For the multi-channel solution to solve the final disposal of sludge, our company is currently carrying out the research on the possibility of sludge entering the landfill fly ash area after dewatering and solidification of sludge based on the principle of sludge stabilization. At present, the results of the pilot test show that the urban sludge, lime and clay in Nanning are mixed and dehydrated in different proportions, and their compressive strength, water content, heavy metal content and other indicators can meet the landfill requirements of the fly ash area. Conduct pilot tests and engineering demonstration studies.

3. Problems and suggestions in the process of sludge treatment and disposal

During the treatment and disposal of sludge from the urban sewage treatment plant in Nanning, our company also encountered some very practical problems, and also proposed some solutions and suggestions for peer reference:

3.1. Must reduce the moisture content of the sludge

At present, the sludge of our sewage treatment plant is dehydrated to 80% moisture content, and then shipped to cement enterprises and composting enterprises, the following problems exist:
Due to the high water content, the transportation volume and transportation cost are increased. For example, the Jiangnan Wastewater Treatment Plant can transport sludge up to 25 vehicles a day, and the sludge transportation rate can be significantly reduced after reducing the moisture content of the sludge.

After entering the cement plant, the sludge with water content of 80% can be pumped to the decomposition furnace through the plunger. Although the transportation is convenient, the high water content also increases the disposal cost of the cement enterprise. According to the analysis and statistics, the cement enterprise of Nanning City The sludge of our company is treated according to a 150 t wet mud meter in a cement kiln. The standard coal consumption of cement clinker is increased by about 5 kg/t, and the power consumption is increased by about 1 kwh/t.

After the sludge with water content of 80% enters the composting enterprise, it must be subjected to secondary dewatering. After the water content is below 60%, the aerobic composting can be carried out, which increases the processing difficulty and treatment cost.

At the present stage, there are three types of sludge disposal and disposal methods in our company: cement kiln co-incineration for building materials utilization, aerobic composting for land use, and landfill fly ash area landfill research. Therefore, while considering reducing the moisture content of the sludge, factors such as not reducing the organic matter content of the sludge should also be considered.

To this end, the third phase expansion project of the Jiangnan Sewage Treatment Plant designed by the Beijing Municipal Engineering Design and Research Institute Co., Ltd. is a bioleaching + plate and frame filter press dewatering process. Our company conducted a pilot test at the Jiangnan WWTP. The results of the pilot test showed that the moisture content of the original sludge of Jiangnan WWTP can be stabilized below 60% after bioleaching and deep dewatering by plate and frame filter. It is yellowish, basically odorless, and the organic matter content is basically unchanged. The sludge treated by this process will reduce the transportation cost. It is also expected to reduce the standard coal consumption and power consumption of co-incineration, and it will also simplify the aerobic composting. Handle the disposal process.

3.2. Improve the disposal capacity of sludge treatment and disposal companies and find more efficient methods

At present, the capacity of cement enterprises to dispose of sludge is 300 t/d, and the capacity of composting enterprises to treat sludge is 200 t/d. With the continuous development of Nanning, the amount of sewage and sludge generated in the central city is getting larger and larger. It is estimated that in 2030, the amount of sludge produced by the urban area of Nanning downtown area will reach about 1300 t/d. Enterprises will not be able to effectively dispose of such a large amount of sludge. Therefore, how to find other safer and more effective sludge treatment methods and outlets is a problem in the future.

3.3. Joint dispatching of sludge treatment and disposal enterprises

As a sludge-producing enterprise, our company not only has to coordinate with the sludge transportation enterprises, but also needs to co-schedule with the processing and disposal enterprises, and also needs to jointly dispatch transportation and disposal. In the process of sludge transportation and disposal, there have been cases where the sludge is not transported in time due to untimely transportation (vehicle maintenance or failure), or the disposal is not timely (equipment overhaul, accident, etc.), and only the second settling tank can be reduced. Or the sludge in the sequencing batch tank, the MLSS of the biochemical pool is up to 11000 mg/L due to the inability to discharge the mud in time and effectively, and the sludge is accumulated in the plant, which adversely affects the normal production of the sewage plant. Therefore, how to coordinate and solve the problem of joint production scheduling of producers, transporters, and disposal parties should be given sufficient attention.
3.4. Strengthening sludge treatment and disposal enterprise collaboration
At present, the sludge generated by the domestic sewage treatment plant in Nanning is not classified as hazardous waste. The triple-single system is adopted. At the sludge loading point of our company, high-definition cameras are installed at the factory gates for monitoring. Each sludge transport vehicle is monitored. Install GPS satellite positioning and on-board high-definition camera (4 sets per vehicle) to record driving routes. Our company also conducts regular inspections of sludge transport vehicles on a regular or irregular basis, and regularly conducts spot checks on sludge disposal enterprises and implements production conditions. View the relevant production record report, strictly require the transportation enterprise and the disposal and disposal enterprise to execute according to the signed contract, and ensure the safe transportation, treatment and disposal of the sludge to the utmost extent.

However, we should see that under the general environment of the market economy, after the enterprises and enterprises sign contracts with each other, the two sides have an equal cooperative relationship. The production and operation of the enterprise are independent. One enterprise has no way and no power to do the other. The internal production and operation of an enterprise will be completely intervened. How to further strengthen the supervision of transportation in the future, how to further supervise the timely and effective disposal of sludge by sludge disposal enterprises, and how to further share information and disclose it is a problem that must be further emphasized and studied.

Nanning City has started the research on the construction planning of the Nanning Circular Economy Industrial Park. The projects include: waste incineration power plant, landfill, garbage transfer station, kitchen waste resource chemical plant, manure treatment plant, sludge resource treatment plant, garden Waste recycling plant and supporting management facilities and other parts. It can achieve the harmlessness, reduction and resource utilization of domestic garbage, sludge and kitchen waste in Nanning City. On this basis, if Nanning City has formulated a local policy to allow sludge production enterprises to transport and the sludge generated by the treatment and treatment forms a sludge treatment recycling industrial chain that processes sludge treatment and disposal sludge, which not only facilitates sludge transportation and treatment and disposal, but also reduces the difficulty of supervision.

3.5. Reduce treatment and disposal costs
At present, all the costs of sludge treatment, transshipment and final disposal in Nanning City are all borne by our company. In 2016, the cost of our company to pay for sludge transfer and treatment enterprises is about 41 million yuan, 2017 The annual average is about 47 million yuan, an average annual increase of 14.6%. At present, both the sludge transfer enterprises and the sludge treatment and disposal enterprises reflect that the price of the payment is too low to meet the daily transportation and disposal expenses. Therefore, relevant departments should increase funding support for sludge transportation and treatment, and improve the enthusiasm and responsibility of sludge transportation enterprises and sludge treatment and disposal enterprises for sludge treatment, disposal and transshipment [4].

4. Conclusions
When determining the sludge treatment and disposal methods of the city, the sludge production enterprises must combine the local conditions, the local conditions as the principle, the government policy as the guide, and the relevant design specifications as the basis. The final disposal method will be determined first, and then the research will be carried out. And to determine the sludge treatment technology, we believe that for sludge treatment and disposal, no way is the best, only the most suitable. It can be said that the final disposal mode of the sludge determines the treatment route of the sludge. It is unscientific and irresponsible for a city or region to talk about sludge treatment without determining the final disposal direction of the sludge. The final treatment and disposal of sludge from our municipal sewage treatment plant is based on the principle of adapting to local conditions in the government and relevant departments, giving full play to the geographical and industrial advantages of Nanning and formulating relevant guiding policy documents. And land use-based treatment and
disposal methods, although these two treatment methods may not be the best and most economical, but at this stage is more in line with the actual and operational operability of Nanning.

The selection of sludge treatment and disposal methods in the urban sewage treatment plant of Nanning and the five measures cited in the process of joint transfer have a guiding significance and practical significance for the treatment and disposal of sludge in the whole city sewage treatment plant in Guangxi. The sludge mentioned in the paper, the problems of untimely disposal, high water cut rate, joint dispatching, etc. are common problems faced by each sludge generating enterprise. The paper gives practical solutions and provides useful benefits for sludge treatment and disposal in other cities in Guangxi.

The sewage treatment of our sewage treatment plant is mainly based on co-disposal of cement kiln and aerobic composting. At the same time, research on sludge entering the landfill fly ash area is being carried out. For other treatment methods such as anaerobic digestion and garbage, there are not many studies on the treatment and disposal technologies such as co-incineration, dry incineration, low-temperature drying, and other more effective composting technologies. In the future, under the guidance of governments at all levels and relevant departments, our company will unite experts from within and outside the region to strengthen research on treatment and disposal technologies for municipal sludge, and find more efficient and safe disposal and disposal methods for urban sludge in Nanning.

Acknowledgement
This research is under the Fund Project Research and Technology Development Plan of Qingxiu District, Nanning City: “Study on Key Technologies of Activated Sludge Solidification Treatment Based on Solid Waste Harmless Treatment Technology” and the item number is 2017012.

References
[1] Zhang C and Li C G 2015 Reconstruction and Expansion Design of Sewage Treatment Plant 2nd Ed. (Beijing, China: China Building Industry Press)
[2] Wang W, Zhu N W and Zhang S F 2015 Discussion on the status quo and prospects of sludge building materials utilization China Water Supply Drain. 2015 40-4
[3] Yu J, Gao D, Liu H T et al 2012 International development trend and prospect of urban sludge land use China Water Supply Drain. 2012 28-30
[4] Yu J, Tian N N and Wang K J 2008 New ideas for sludge treatment and disposal technology in urban sewage treatment plants China Water Supply Drain. 2008 28-30