Application of Integrated Technology of Ecological Dredging and Silt Disposal in Comprehensive River Management

Cao Jialin¹, Yang Hao¹, Shi Chengming², Li Feihang¹, Sun Chenghe¹, Zhang Cheng¹, Yin Hui³*

¹ SinoHydro Foundation Engineering Co., Ltd. (Wuqing, Tianjing), No. 86, Yongyang West Avenue, Wuqing District, Tianjing City, China
² PowerChina Eco-Environmental Group Co., Ltd. (Bao'an, Shenzhen), No. 1003, Xin'an No. 6 Road, Bao'an District, Shenzhen City, China
³ Zhejiang University of Water Resources and Electric Power, No. 308, No. 2 Road, Jiang'gan District, Hangzhou City, Zhejiang, China
* Corresponding author's e-mail: 85763440@qq.com

Abstract: Multi-process such as environmentally friendly cutter suction dredgers are used for river silt cleaning, pipeline pumping, coagulant (PAM) dosing, geotextile tube dehydration and solidification, leachate collection, multi-stage coagulation sedimentation treatment, residual water treatment are adopted to comprehensively control the water quality and silt of the Fu River New District in Anxin County, Xiongan New District. The treated residual water is discharged to Fu River after the test meets the standard, and the silt is solidified and then further comprehensively utilized as resources. Through the design and the whole process of tracking practice in the test phase of this project, the integrated technology of ecological dredging and silt disposal was explored for the construction technology and operation process of river dredging and sediment dehydration and volume reduction, providing reference for standardization and large-scale application of similar projects.

1. Introduction
The siltation of small and medium-sized rivers in China is relatively common, and the original capacity of the rivers to regulate floods and prevent and reduce disasters has been weakened. In recent years, China has strengthened the governance of small and medium-sized rivers and rural rivers, among which dredging projects have been widely implemented as the main measure[1]. In the comprehensive treatment of rivers, river dredging and silt treatment are very important basic works. How to use new technologies and methods such as ecological dredging equipment and silt treatment to protect the environment, improve water quality, reduce the impact of the project on the water environment, realize ecological dredging and comprehensive utilization of resources while doing a good job in river dredging construction, which are of great significance to regional ecological construction and sustainable development[2].

2. Project overview
The River Course Comprehensive Treatment Project of Fu River New District is located in Anxin County, Xiongan New District. It runs from east to west, starts from the boundary of Xiongan New District in the west, and ends at Anxin Bridge in the east. The treatment length of the river is about 16.30 km. The width of the river course is about 20.00 m-110.00 m, the width of the water surface is about...
The range of river dredging is from the junction of the Fu River and the boundary of the new district to the whole section of Anxin Bridge with a total length of about 16.30km. The width of the river course varies from 20 to 80m, the sediment depth of the river bottom is 0.1 to 0.5m, the average dredging thickness is 40cm, and the total dredging volume is about 180,100 m³. The sediment dredged from the river is solidified, and then it will be used for resource utilization, mainly for garden soil and building materials (Fig.1).

![Fig.1 General layout plan of the comprehensive treatment project of Fu River New District](image)

**3. Construction technology**

The dredging test period adopts an environmentally friendly cutter suction dredger, which is pumped into the geotextile tube through a pipeline for dehydration and solidification\(^\text{[3-7]}\). The leachate is collected through the drainage ditch, processed through multi-stage coagulation and sedimentation treatment, SBR residual water treatment and other processes, and then discharged to Fu River after the test reaches the standard. The specific construction process (Fig.2):

![Fig.2 Specific construction process](image)
3.1. Construction technology of underwater cutter suction method

3.1.1. Environmentally friendly cutter suction dredgers. According to the construction conditions, an environmentally friendly multifunctional cutter suction dredger is selected, and its model is: 6-inch environmentally friendly cutter suction dredger. The main parameters are configured as follows:

Tab.1 Main parameter configuration table of environmentally friendly cutter suction dredger

| Serial number | Item                  | Model                  | Quantity | Remarks                                |
|---------------|-----------------------|------------------------|----------|----------------------------------------|
| 1             | Main hull             | /                      | 1        | 15m in length, 3.8m in width and 1m in depth |
| 2             | Gantry                | 140 seamless tube      | 1        | 4m in height and 3m in width           |
| 3             | Spud                  | 12mm seamless tube     | 2        | 325mm in diameter and 12m in length    |
| 4             | 10-inch horizontal dredge pump | ES-10G          | 1        | Clear water discharge 800m³/h, lift 45m |
| 5             | Marine reduction gearbox | Hangchi 30               | 1        | staged                                |
### 3.1.2. Environmental protection measures for cutter suction construction

In view of the possible impact on water quality, the following river water quality protection measures are formulated:

1. **Install anti-fouling screens as isolation curtains at 200m, 400m, and 600m downstream of dredging operation area of the cutter suction dredger, forming a relatively closed dredging operation area, isolating most of the diffused pollutants in the operation area and allowing them to settle, so as to reduce the impact on the water quality of downstream rivers.** The anti-fouling screen needs to meet the following requirements: 800 grams of PVC leather, 320 grams of filter cloth, thickness of PVC cloth of 0.65mm and width of 2m (Fig.3).

![Fig.3 Effect picture of anti-fouling screen](image1)

![Fig.4 Protective cover of cutter head](image2)

2. **In the process of dredging, the environmental protection cutter head is used, and a protective cover is installed on the periphery of the environmental protection cutter head. The semicircular anti-fouling envelops the cutter suction gear, and has a downward bell mouth shaped opening to prevent the muddy mud from floating up and diffusion (Fig.4).**

3. **When dredging the floating mud layer, the method of only sucking and not digging is adopted.** The mud pump is used to directly suck the floating mud so as to reduce the disturbance of the excavation head. For the thicker mud layer, digging by layers method is adopted to reduce the thickness of the dredged mud at one time to prevent the spread of excessively stirred bottom mud when not being completely sucked away by the dredger pump.

4. **The method of backwater dredging is adopted to ensure that all the silt enters the cutter suction pump and is sucked out of the river bottom.** In the operation, before dredging the silt, turn on the pump and then the cutter head, so that the muddy water can be sucked out in time. When stopping, first turn off the cutter head, and then stop the pump, so that all the muddy water can be sucked out.

5. **Before dredging the silt, first turn on the pump and then turn on the reamer for operation.** When stopping, first stop the reamer, and then turn off the mud pump to ensure that all the silt and muddy water are sucked out.

### 3.1.3. Sediment transportation

This project mainly adopts environmentally-friendly cutter suction dredgers to mix the excavated contaminated bottom mud with water into mud, and then send the mud through a mud pipeline to the bottom mud treatment site for subsequent treatment. The pipeline for conveying sediment in this project adopts high-molecular-density PVC pipes, and the mud pipe is divided into three types: floating pipe, shore pipe and submerged pipe. The fully enclosed pipeline transportation technology eliminates the scattering and leakage of silt transportation, and allows flexible selection of silt stacking locations. At the same time, water conditions can be used to lay underwater submerged pipes to the greatest extent. The connection of the mud conveying pipe on the water is tightly sealed, and there should be no mud leakage, which reduces the interference impact on the environment (Fig.5).
3.2. Dehydration process

This project adopts geotextile tube dehydration method to dehydrate the bottom silt, and its technological process (Fig.6):

3.2.1. Layout of the delivery pipeline in the dehydration area. After the dredger uses pipelines to send the silt into the mud settling pond in the sediment treatment site, the flocculant is added to the flowing mud, and the mud mixed with the flocculant is quickly filled into the three geotubes by cutter suction pump, and then filled into the draining geotube.

3.2.2. Geotextile tube. Geotextile tube is the main material for the mud dehydration of this project. The material is 500g/m² high-strength polyethylene filament woven fabric with plain weave, and its tensile strength is 50kN/m. The sewing of the geotextile tube adopts two fold stitches. Geotextile tube size: 50m in length, 30m in circumference of cloth tube, 300mm in diameter of mud inlet cuff to ensure smooth insertion of mud pipeline.

3.2.3. Mud filling method. When filling the geotextile tube, first start filling with mud from one end of the cuff. During the filling process, it is necessary to check the mud and sand accumulation at the mouth of the mud pipe. When filling, manually step on the top surface of the tube body to rearrange and tighten the mud particles, to ensure that the filling is flat, and to accelerate the drainage and consolidation speed of the tube body. When the entire tube reaches the grouting stage, reduce or stop filling appropriately to prevent the tube from bursting, and leave a certain consolidation and dehydration time.
3.2.4. Dosing method. The dosing equipment adopts a dosing machine, whose dosing capacity matches the mud conveying capacity. The flocculant is fully mixed with the silt in the mud settling pond through the dosing pipe and mixer and filled into the tubes to speed up the silt dehydration time.

3.2.5. Site layout of dehydration area. The area is respectively arranged into the mud settling pond, the dehydration area, the regulating pond, the settling pond, the storage pond, the SBR treatment facility, the purified water storage pond, etc. The geotextile tube is planned to be stacked in 2 layers, and the average height of each layer after dehydration is 1.6m. 4 to 5 rows of geotextile tubes are regarded as a dehydration unit. Drainage ditches are set up in both directions around the dehydration area and the dehydration unit. The section size of the drainage ditch is 50cm×50cm. The drained water is directed to the residual water treatment area for treatment.

3.2.6. Residual water pollution protection. In consideration of the pollution of sediment leaching water, it is necessary to protect the temporary site from secondary pollution, and build an impermeable layer in the geotextile tube dehydration site to avoid polluting the surrounding environment and groundwater during the dehydration process. The impermeable layer at the bottom of the field is as follows from bottom to top: the foundation of the field, 600g/㎡ composite geomembrane, and 20cm thick pebble discharge guiding layer. Drainage ditches are set up in both directions around the sediment treatment field and the dehydration unit. The cross section size of the drainage ditches is 50cm×50cm. The leached residual water is directed to the residual water treatment area for treatment. After each dehydration, personnel should be arranged in time to clean up the muddy water that has accumulated in the ditch and flush it with a water gun to prevent the polluted water from infiltrating. During the draining process, regular supervision and inspection work should be done to avoid large-scale spilling or spreading of polluted water.

3.3. Residual water treatment

3.3.1. Residual water treatment technology. After the mud is drained through the geotextile tube, the solid part is retained in the geotextile tube, and the concentration of suspended solids (SS) in the residual water may still exceed the standard. The pollutants are mainly in particulate form. The main purpose of treatment is to control the content of pollutants. The filtering effect of the geotextile tube has a certain effect on the removal of pollution indicators such as COD and TP. The COD, NH3-N, TP, TN and other pollutants in the residual water still exist so that the residual water cannot meet the discharge standards. Therefore, for the leached residual water, the flocculent precipitation is used again for the first-level enhanced precipitation, and then the SBR integrated water purification device is used to reduce the concentration of COD, NH3-N, TP, and TN in the residual water through chemical agents so as to meet the sewage discharge standards, discharge (Fig.7).

3.3.2. Treatment process and residual water discharge. The residual water after the dehydration of sediment is collected through the drainage ditch (paved with zeolite) and enters the regulating pond. After the water volume is adjusted, it settles for 2 hours in the settling pond. The supernatant after coagulation and settling of the mud overflows to the regulating storage pond. After coagulation treatment, the residual water can be used preferentially for construction water of surrounding projects, landscaping, and road sprinkling to reduce dust. Due to the difference in the degree of sediment pollution in different river sections, the quality of the water entering the residual water treatment system is different. When the influent water quality is good and the precipitation water can meet the discharge standard, the residual water is directly discharged; when the precipitation water cannot meet the discharge standard, the residual water enters the SBR integrated sewage treatment device and is discharged after meeting the standard (Fig.8-10).
During the test, the effluent from the geotextile tube and the effluent from the storage pond is continuously monitored to determine the degree of residual water treatment and whether it meets the discharge requirements.

3.4. Silt treatment
The river silt has the properties of high strength and low permeability after the integrated treatment of solidification, and the solidification material formula can be designed and treated according to the requirements of the project. The solidified silt after treatment has a wide resource utilization path. It can be used as soil for greening, and can also be used as filling material for embankment reinforcement projects, road projects, and sea reclamation projects. In addition, it can be used as burn-free bricks or sintered bricks for engineering construction aspect.

4. Conclusions and recommendations
4.1. The use of environmentally-friendly cutter suction dredgers combined with geotextile tubes to dredge and dehydrate the river sediments has the technical characteristics of high degree of mechanization, secondary pollution control, and low moisture content of the sediments after dehydration. Environmental-friendly dredging has high dredging accuracy and little disturbance to the overlying water. The silt is transported in a closed pipeline to avoid secondary pollution. By adding flocculant (PAM), the geotextile tube can intercept the solid particles in the sediment as much as possible. After dehydration, the water content of the sediment can reach below 50%, the properties are greatly improved, the transportability is strong, and the engineering dehydration cycle is shorter.
4.2. The amount of dredging and silt treatment capacity depend on the production capacity of the equipment, and the dehydration and solidification of silt requires a large amount of storage yard. A larger site area is required for large-scale river dredging projects.

4.3. The residual water treatment design of the system ensures the discharge up to the standard. But from a more economical point of view, considering that the pollutants are mainly particulate, the optical automatic tracking system can be used to determine an economical and reasonable residual water discharge threshold according to the light transmission of different residual water's turbidity. When the threshold is reached, the system automatically discharges. If the threshold cannot be reached, the return pipeline is opened and the residual water re-enters the settling equipment for treatment to ensure that the residual water treatment can meet the ideal discharge standard.

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