

Influence of waterway dredging engineering on Water Ecological Environment and Countermeasures

Changbing Liu, Hongxia Xiong*, Wei Huang and Yu Lin

Tianjin Research Institute for Water Transport Engineering, Key Laboratory of Environmental Protection in Water transport Engineering, Ministry of Transport, Tianjin 300456, China

Abstract. During waterway dredging engineering due to the disturbance of construction operation on water, the original substrate will change and suspended solids will concentrate sharply in a short period of time resulting in the change of local ecosystem and river habitat landscape and bring adverse impacts on aquatic organisms. This paper expounds the ecological characteristics of waters in the area of dredging engineering. Combining with the overall requirements of water ecological environment protection, the paper analyzes the impact of waterway engineering on the ecological environment and puts forward relevant countermeasures and suggestions.

1 Introduction

With the rapid development of economy and society and the building of waterborne transport and infrastructure in China, coast and river basin have increased the exploitation and construction of water transport to meet the growing cargo traffic and the need for large vessels, so the waterway became more deepwater. The waterway dredging, as one of the main measures of maintenance waterway, its application is more and more widely, which will make some influence to aquatic ecosystem^[1]. Through analyzing the influences of the constructing to phytoplankton, zooplankton, benthos and fishery resources, especially the focus on the influence of the reef blasting to aquatic ecosystem, and the constructing to the habitat of rare aquatic ecosystem and to the migration pathway, according to the order of preventing, alleviating, restoring and compensating, the measures of the aquatic ecosystem protecting were put forward to avoid and alleviate the influences of the waterway dredging in inland waterway to aquatic ecosystem, so as to provide some experiences in the environment protecting of the waterway dredging in inland waterway.

Hundreds of cubic kilometers of sediment are dredged each year for commercial and recreational purposes and discharged into nation's oceans, estuaries, rivers and lakes, or to land-based disposal facilities. Dredged materials are invaluable resources for construction, coast protection, agriculture and aquaculture and stabilizing or restoring wetlands and beaches; and method of wetland restoration using uncontaminated dredged materials are either straightforward or are in development. Coastal ecosystems providing vital natural services to society have been severely damaged by development.

2 Influences of waterway dredging engineering on ecological environment

2.1 Influences of waterway dredging engineering on aquatic ecosystem

In order to maintain the navigating standards of waterway and improve the sediment deposition conditions, it is necessary to dredge the waterway at

regular intervals. However, suspended particulate matters may be generated easily from agitation and leakage in the process of construction, which may increase the turbidity of the constructing areas as well as its surroundings, result in the dissolved oxygen content and the light transmittance of water body. So the waterway dredging engineering will produce the adverse effects on the growth and reproduction of aquatic organisms^[2].

2.1.1 Effects on phytoplankton

During the waterway dredging, the dredging spoiling will result in the concentration of suspended particulate matters rising and then reduce the dissolved oxygen content and the light transmittance of water body, which will produce the adverse effects on the photosynthesis, then effects on the type and quantity of phytoplankton.

2.1.2 Effects on zooplankton

The waterway dredging project increased the concentration of suspended particulate matters. The suspended particulate matters will adhered to the surface of zooplankton and interfere with their normal physiological function, especially for those of filter-feeding zooplankton, they swallowed the sizable suspended particles and caused the disorder of internal digestive system, and finally resulted in the death of zooplankton.

2.1.3 Effects on benthos

The benthic organisms are generally small size and slow activity species. They are usually natural food to fish, shrimp and so on. So the species and amounts of zooplankton are relented to omnivorous fish. With the port plays a more and more important to regional economic development, the development of large scale harbor requirements deeper navigation water depth. The waterway dredging project changed the flow of water, and destroyed directly the benthic habitat, which will produce some effects on the species, distribution and amounts of zooplankton. In addition, most of the zooplankton living the construction area will dead during

construction, which will bring serious damage to the benthic animals throughout the construction area.

2.1.4 Effects on fishes

With the concentration of the suspended particulate matters rising in water, the suspended particulate matters enter into the gill following breathing, then deposit on the gill flap, gill and gill lamellae, which not only damage the gill tissue, but also block gas exchange and cause fish death. Adult fish have the strong harm avoidance ability. The adult fish will initiatively avoid the interference during the waterway dredging. Larvae and juvenile are more sensitive to the concentration of the suspended particulate matters than the adult fish. So the suspended particulate matters resulting from the waterway dredging have affects mainly on the larvae and juvenile.

3 The environmental protection of waterway dredging and countermeasures

3.1 Aquatic ecology environment conservation and protection

During the waterway dredging, the construction units should carry out overall process construction supervision and environment monitoring to understand the influences of dredging on the aquatic ecosystems to adjustment the work program timely to prevent damage to the ecological environment of the river. Meanwhile, the construction units should consult with the fishermen near the dredging point about the working hours to reduce the loss of fish stocks in the area.

The construction units should immediately stop construction if they found or hurt the rare aquatic animal, then reported to the fisheries administration. The construction units can install the artificial spawning bed, habitats, migration channels and artificial releasing to retrieve the aquatic ecology. The main stress of inland waterway regulation project was changing the biological habitats and ecological conditions. So the main repair measures were aquatic species enhancement and releasing.

3.2 The ecological environmental conservation and utilization technology of waterway dredging sediment

The viewpoint that the dredging sediment is a kind of available resources has been accepted by all walks of life. The construction units should mensumte the physical and chemical characterizations of the dredging sediment to determine the pollution level of the dredging sediment, and then develop the different disposal methods. Beneficial use of dredged material includes 'all productive and positive uses of dredged material, which covers broad use categories ranging from fish and wildlife habitat development, to human recreation, to industrial/commercial uses'^[3].

3.2.1 Constructions

Land creation or reclamation can use large volumes of dredged material mixed with other construction material. Dikes and dams can be constructed if there is a high content of clay in the dredged material. Some dredged material can be converted into bricks or mudcrete for construction. This is normally expensive due to the necessary treatment and only beneficial if there is a market for this type of product. This process is used when the dredged material has to be removed and treated regardless such as in removal of polluted sediments.

Biodegradable geotextile containers filled with dredged material can be used as supports for other dredged material in river stabilisation schemes and other river training works. Again, there is an added cost due to the time and specialised equipment needed.

3.2.2 Repair severely disturbed land

The content of nutrients were high in dredged sediment but it was unbalance. Contents of organic matter, phosphorus and potassium were high in dredged sediment, while that of nitrogen was low. Decompose of organic matter was rapid when the dredged sediment applied to soil, while available phosphorus providing was permanent. Contents of heavy metals in dredged sediment were significantly lower than sewage sludge and most of them lower than Agriculture Application Standard, so it is more economical to apply dredge sediment to land directly. So it could be concluded that dredged sediment can be used as fertilizer or amendment to reclaim land when the species of plant and application rate are properly selected.

3.2.3 Garden soil

Dredged sediment which is composed of upland soil enriched with nutritive organic matters could be used beneficially as soil amendments or manufactured soil for horticultural use rather than discarded as spoil material. Dredged sediment used as soil amendments could improve the physical and chemical properties and fertility of soil, and so to promote plant growth. In addition, the garden plants generally do not enter the food chain, so it is not easy to cause food chain pollution hazards.

3.2.4 Coast protection

Rises in sea level increase the erosion of coastlines, tidal estuaries and man made sea defences. Mudflats and saltmarshes act as dissipaters of wave energy and can be directly replenished with dredged material. Careful placement of the dredged material is necessary to ensure that the correct shape profile is formed to prevent excessive erosion in certain areas. Large volumes of dredged material can be used in this process but the change in biological properties of the mudflat may have detrimental effects on the environment. Material placed at

an offshore location can use natural erosion processes to nourish the area – known as trickle charging. Often, the placement of supporting structures to prevent gravitational forces from moving this fine sediment are used – known as onshore feeding.

Beaches can be nourished and replenished as well as strengthening offshore berms to decrease further erosion. Hard berms are either submerged or above-surface permanent structures that directly block waves reducing the energy that reaches the beach. Soft Berms are underwater mudbanks that absorb wave energy through attenuation. Severe tidal conditions can spread the mudbanks causing environmental problems. Feeder berms are placed upstream of the beach. Natural processes erode the berms and the sediment is carried downstream to nourish the beach. This is similar in theory to trickle charging. Berms can also be used for protecting mudflats and saltmarshes.

3.2.5 Restore the deteriorated wetlands and Create artificial ecological islands

Dredged marine sediments, which are traditionally discarded by open sea disposal, have historically been one of the main marine pollution sources. It is therefore of great value to investigate the beneficial use of these sediments for coastal ecological engineering applications^[7-11]. Historically, the USACE placed dredged material in open waters and wetlands near Federal channels, provided the material would not become a navigation hazard or readily slump back into the channel. In 1973, the USACE initiated the Dredged Material Research Program (DMRP), authorized by the Rivers and Harbors Act (RHA) of 1970. This program examined the effects of dredging and dredged material placement on fish and wildlife habitats and developed recommendations for how those habitats could be enhanced or created with dredged materials^[4-6]. The potential use of dredged materials includes enhancing the sediment budget at low elevations, reintroduction of tidal effects, and improving the geomorphology of the marsh plant forms. Artificial islands may be created with dredged marine materials, and different types of habitats are developed with various elevations to provide nesting and refuge habitats for birds and other wildlife. Historically, many dredged material islands originally created based simply as a convenient placement option have developed naturally into productive and valuable wildlife habitat, supporting abundant biodiversity and various habitats. Dredging sediment can also strengthen the embankment.

The rapid development of our country water transportation enterprise vigorously promoted the development of our country's economy, waterway dredging, as one of the main measures of maintenance

channel, its application is more and more widely. The dredged spoil will be some destruct effects on the marine ecological environment and fishery resource. Most of the dumping is the earth clay that is eroded away, and is the valuable inartificial resource. The dumping to other site because of the engineering requirments brings large degree waste on resource and energy. There are many kinds of ways of beneficial use of dredge sediment including the blowing of dredger fill to reclaim land and the feeding of sand of wetland protection, which will be the future development direction of dredged sediment disposal in navigation channel.

4 Discussions

There are many factors that affect the success of a project and often they are specific only to the project in question. The property that most affects the suitability of dredged material for a project are physical such as grain size, water and organic content. Ecologically, laying different sand or silt can alter the organisms that inhabit that area. Morphologically, the use of different material type can have affects that drastically change the physical evolution of the area. There are other concerns about the load bearing ability of different dredged material when used in construction.

Chemical and biological properties also affect the suitability of dredged material especially in projects for agriculture and habitat creation. These factors may also result in ecological concerns: long term possibly permanent impacts to the system either morphological or biological; damage or smothering to the existing or adjacent sites; increase in turbidity. Another factor hindering the use of projects on a large scale is uncertainty. The replacement of one habitat with another is always risky but could be fundamental in achieving long term solutions especially in coastal defence.

If beneficial uses of dredged material are adopted on a larger scale, the associated problems will be reduced through an increase of knowledge surrounding the issues. The economic benefits could themselves ignite this need but it is more likely that an outside stimulus will be required. Further environmental legislation could ensure that appropriate investigation is undertaken for beneficial use of dredged material-possibly an additional cost for not finding an alternative use. However, this also needs to be supported by an increase in the science and knowledge behind such projects to enable the refusal of disposal of dredged material at sea.

Acknowledgements

This work is supported by special fund for basic scientific research business of central public research institutes TKS 130103.

References

- [1] Z.L. Xu, M. Li, Q. Gao and H. Chen. Mar.Environ. Sci. **29(5)**:617-625 (2010)
- [2] H.T. Wang, Y.H. Zhou and Y.G. Liu. Coast. Eng. **33(1)**: 43-50. (2014)
- [3] USACE. US Army Corps of Engineers, Office of Engineers, Washington, DC. (1986)
- [4] Landin, M.C. US Army Engineer Waterways Experiment Station, Vicksburg. (1982)
- [5] Landin, M.C., Webb, J.W., Knutson, P.L. Technical Report D-89-1, US Army Engineer Waterways Experiment Station, Vicksburg. (1989)
- [6] Lunz, J.D., Diaz, R.J., Cole, R.A. Technical Report DS-78-15, US Army Engineer Waterways Experiment Station, Vicksburg. (1978)
- [7] S.B. Cui, J.Y. Liu, J. Chen and Q.J. Chen. China Water Resources, **21**: 16-19 (2005)
- [8] G.R. Yu, Z.Q. Xia, Y.P. Cai and W.G. Yu. . Hohai Univ. (Natural Sciences) **34(6)**: 618-621 (2006)
- [9] H.M. Huang, J. Xie, Q.S. Lou and Y.X. Wang. Mar. Environ. Sci. **30(6)**: 866-871 (2011)
- [10] H.M. Huang, Y. Gao and Y.X. Wang. Acta Ecol. Sin. **32(8)**: 2571-2580 (2012)
- [11] Y. Xu. Port & Waterway Engineering, **8**: 33-38 (2007)