2014

ISSN : 0974 - 7435 Volume 10 Issue 19

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(19), 2014 [11406-11412]

Impacts of water conservancy projects on estuarine ecological environment

Shouping Zhang
Chongqing Water Resources and Electric Engineering College, Chongqing, 402160, (CHINA)

ABSTRACT

The domestic water resources utilization and development have achieved certain results, such as the large and small water conservancy projects built along the stem stream of Yangtze River and the Yellow River or along their tributaries. Among these water conservancy projects, the Three Gorges Dam is the most magnificent. However, the water conservancy projects will change the ecological environment of estuary, including water, dynamic state of sediment, and nutrient substance. All these changes will have direct impact on the hydrological condition of downstream river. The fundamental reason of the impact of water conservancy projects on estuary environment, aquatic ecosystem, shrink of river delta, salt-water encroachment and coastline erosion is the changes of hydrological condition caused by water conservancy projects. Therefore, it is necessary to track and monitor the aquatic ecosystem before and after water conservancy projects, getting a clear understanding of the relationship among hydrologic condition, water quality, silt and biomass, determining the relevant hydrologic conditions of rivers, lakes, wetland and estuary as well as the mutual relationship among aquatic ecosystems, so as to legally and rationally develop and utilize river resources. The paper analyzes the impacts of the decrease of river runoff and changes of seasonal distribution which are caused by upstream impoundment and water diversion on the transporting capacity of nutrient substance in the water and the self-purifying capacity of water, besides the impact of the decreasing upstream water and sediment on estuarine environment and biodiversity is also taken into account.

KEYWORDS

Water conservancy projects; Ecological environment; Self-purifying capacity; Biodiversity.

INTRODUCTION

In recent years, the water pollution of rivers and lakes in our country has been aggravating and the direct cause is industrial and agricultural pollutant discharge. Moreover, the water storage and coastal engineering of water conservancy projects are also one reason. For example, since 19550 s, there are more than five thousand various types of reservoirs and four thousand sluices built in the Huaihe river basin with fifteen thousand kilometers of dam heightened and consolidated. Although the capacity of controlling water disasters is greatly improved, the self-purifying capacity of river is correspondingly damaged to the extent that the water quality of downstream river seriously deteriorates during dry season.

With the development of the society, especially during the recent 20 years, the water conservancy projects have a bigger and bigger impact on estuarine environment. Take the hydrological environment of Yangtze river as an example. The water quality of the Yangtze river has some obvious changes, such as the increasing content of calcium ion and sulfur tetroxide ion in water, and the decreasing PH value in some river reaches. The continuous transportation of nutrient substance to the estuary and offshore area has seriously eutrophicated the water of offshore area, which results in frequent red tides. The concentration of nitrogen and phosphorus in the offshore area of Yangtze estuary, Hangzhou Bay and Zhoushan islands have greatly exceeded the standard and at the same time, there are traces of toxic and harmful organic compounds existing in the water, which leads to heavy metals pollution. Changes of river runoff, flow rate of water, and sediment discharge which are caused by water conservancy projects all can be the influencing factors.

SELF-PURIFICATION OF WATER

The definition of self-purification of water can be divided into two types. The first type is generalized, referring to reducing the concentration of pollutant in polluted water through physical purification, chemical purification and biological purification to make the water quality recover or roughly recover to the original level. The other is a narrow definition, referring to the process of the microorganism in the water purifying the water through oxidizing and decomposing organics in water.

Based on current understanding, the organic process of self-purification can be divided into three stages. The first stage refers to the chemical oxidization and decomposition of organics which can be easily oxidized. This stage can be completed within a few hours after the pollutants entering into water. The second stage refers to the biological oxidization and decomposition of organics carried out by the microorganisms in water. The duration of this stage depends on water temperature, amount of organics, species and amount of microorganism, thus it may last for a few days. Generally speaking, this process can be completed within 5 days. The third stage refers to the digestive process of nitrogenous organic compound. This process is most time consuming as it can extend to a month or so.

Up to now, the self-purification of water generally has three methods. The first one is a physical process, including the deposition of solid. The dilution and mixing of suspended solids, colloid and soluble pollutants can gradually reduce their concentration. The dilution effect in this process is the first important process of physical purification. The second method is chemical method. In this process, the pollutants will experience a series of chemical reaction including oxidation, reduction, acid-base reaction, adsorption and decomposition, chemical combination. The third is the biological method. The activities of all kinds of aquatic organisms including algae and microorganism, especially the oxidation and decomposition of organics carried out by microorganism in water, will greatly accelerate the degradation of pollutants. Besides, this method plays a very important role in the self-purification of water.

THE IMPACT OF WATER CONSERVANCY PROJECTS ON THE SELF-PURIFYING CAPACITY OF WATER

The estuarine ecosystem is characterized by its unique structure and diversified functions. The changes of the environmental factors of estuary are dramatic as it has fragile and sensitive ecosystem structure. Therefore any significant changes of upstream rivers will have certain effect on estuary. Take the Yangtze river as an example. Since the 1950s, there are about forty-eight thousand reservoirs existing along the Yangtze river. These reservoirs all have certain impact on river runoff and seasonal distribution of runoff. For example, after the completion of the Three Gorges Dam, although the annual quantity of discharging water does not have significant changes, great changes have taken place in the seasonal distribution of runoff. The implementation of these water conservancy projects has certain impact on the changes of the hydrological conditions of estuary including some key factors such as the concentration of nutrients, water quality, self-purifying capacity of water. All these changes will either affect the habitats of aquatic organisms existing in estuary or change the structure, composition and distribution characteristics of biocoenosis. The particular case is shown in Figure 1.

As is known to all, hydrological factors are important environmental factors of the formation and development of marshes and coastal wetland, therefore the upstream water conservancy projects will have a strong impact on the size of wetland, biological diversity and biomass. Generally speaking, the impact of water conservancy projects on estuary ecosystem will be a long, slow, potential and complicated process, which often is the superposition of the impacts of all upstream projects, such as the water being polluted by traces of poisonous and harmful substances.

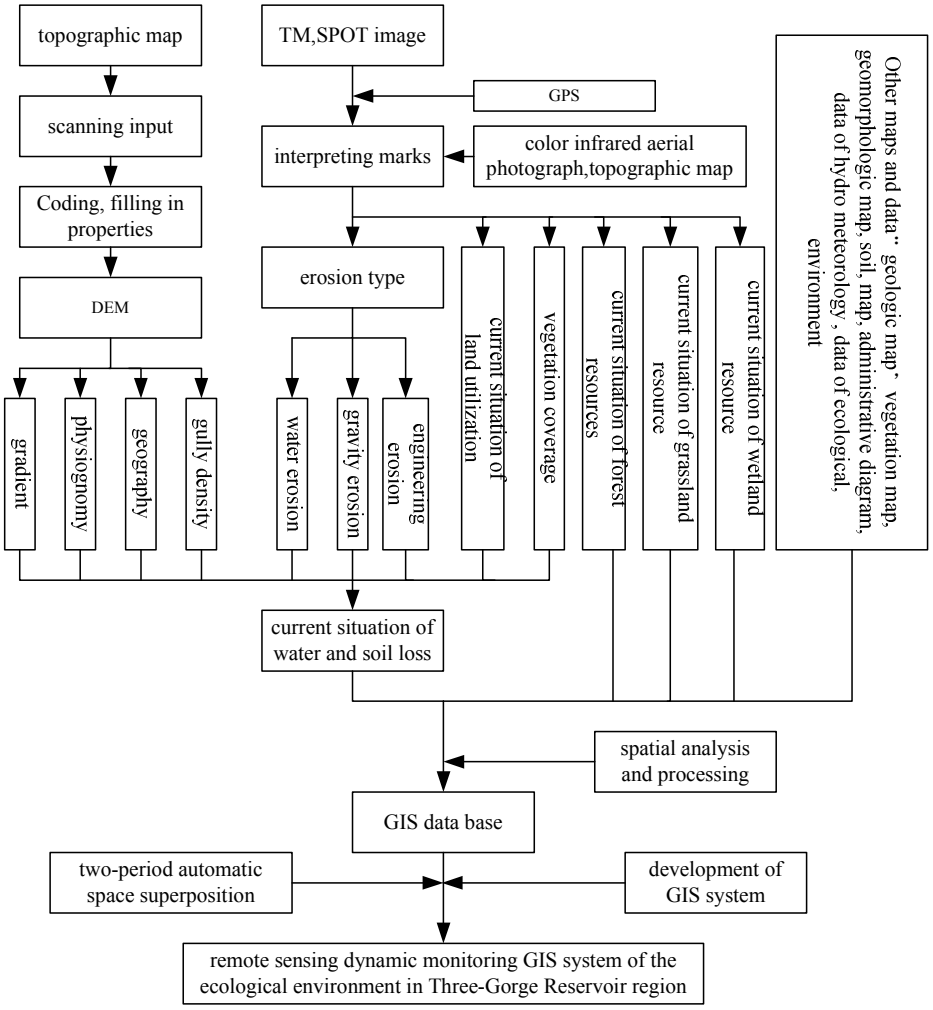

Figure 1 : Remote sensing dynamic monitoring process of ecological environment

THE IMPACT OF WATER CONSERVANCY PROJECTS ON THE ECOLOGICAL ENVIRONMENT OF ESTUARY

The construction of water conservancy projects will change the size of streams, which will lead to sediment transport and sediment deposition. Due to the existence of dams, a large amount of sediment may be intercepted in internal reservoir and detained, which will inevitably lead to the reduction of downstream sediment and change the graded composition of sediment. Moreover, the changes of water and sediment will certainly affect nutrient substances contained within them. The changes of nutrient substances will lead to the changes of th1 amount of fish populations, which generally will result in a decline in fishery production.

Generally speaking, the characteristics of species in estuary vary from season to season because the aquatic organisms usually are closely related with the river runoff. There are a large amount of nutrient substances existing in river, namely the food of aquatic organisms. The construction of water conservancy projects reduces the river runoff, which leads to a decrease in the sediment carrying capacity of river. All these changes will change the concentration of nutrient substances in estuary, which ultimately affects the amount of creatures. The spawning and growth of migratory fishes are directly related with water quantity and flow velocity. Generally, the overflowing river or the long-playing flood will promote the sexual maturation of migratory fishes, leading to an increase in the amount of roes. If the upstream water conservancy projects have proceeded adjustment, the seasonal change of the river will tend to be placid, which will affects the normal life habits of migratory fishes. Here are some examples which respectively are the Nile river, the Yellow River, and the Yangtze river. Figure 2 is the structure chart of the environmental protection files of various counties and cities.

There are over ten reservoirs already built and under construction along the Yellow River. Although these reservoirs will reduce flood discharge and flood damage, it should be made sure that there is certain river runoff during dry season so as to maintain the normal water surface and water depth. However, in fact, the impoundment of reservoirs, cascade development on both sides of the Yellow River and low rainfall of the upstream Yellow River have lead to the frequently drying up of Yellow river, which has seriously damaged ecological environment of downstream Yellow River. In fact, with the reduction of the river runoff of the Yellow River and the decrease of the condensation of nutrient substances contained in water, the

biomass in estuary has been reducing rapidly, which leads to the continuous reduction in fisheries production of the Yellow River after 1960s.

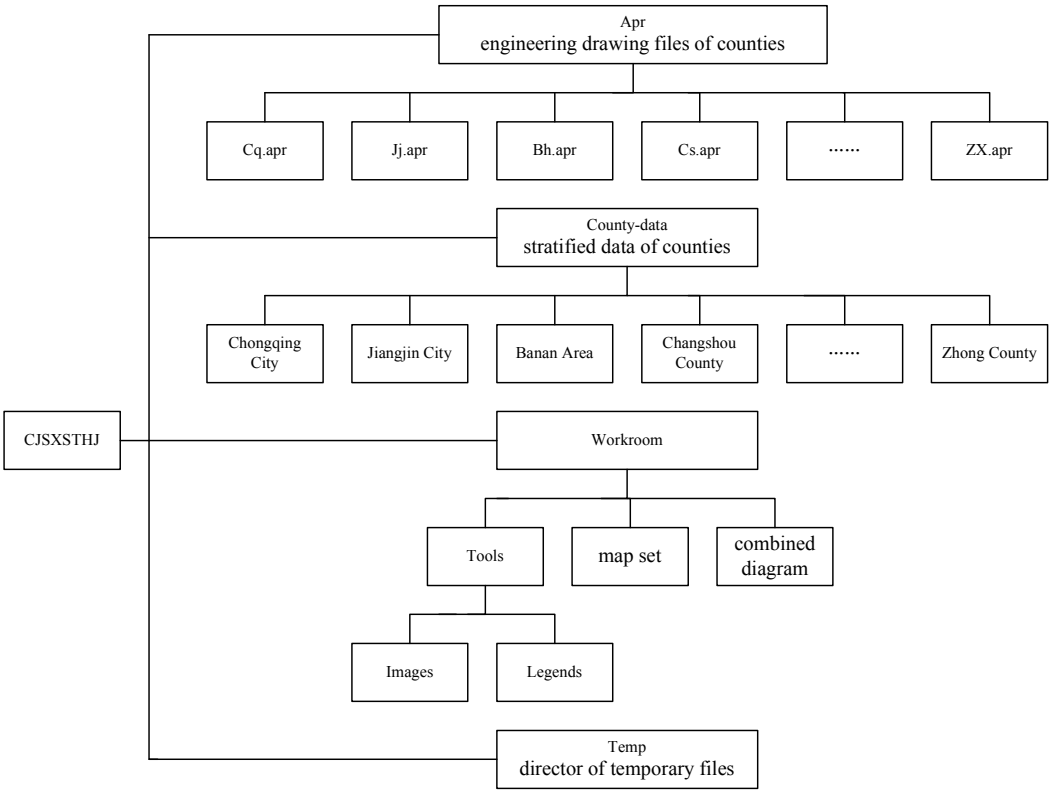

Figure 2 : The organizational chart of files

THE IMPACT OF WATER CONSERVANCY PROJECTS ON MARSH WETLAND, RIVER DELTA AND COASTAL WETLAND

Generally, there are grass or forest belts growing on both sides of rivers. As a transition zone, the grass or forest belts are the last defensive line preventing pollutants from entering into the water. The defensive line can decrease the content of organics, suspended solids,and phosphorus entering into water through a series of effects including soil adsorption, plant absorption, biodegradation. In fact, the estuary coast, lakes, coastal mudflat and wetlands play an important role in improving the environment and water quality. In addition, they also have a significant role in reducing flood, biodiversity conservation, environmental greening, improvement of the ecological landscape. However, some existing human activities in our country, including turning lakes into fields, building dams, transforming water network, will exert a huge damaging impact on the above environment.

It can be seen from the study that the reduction of wetland is closely associated with the hydrological environment. The impoundment or water diversion at upstream river will change the river runoff, thus redistributing the river runoff. The loss of self-distribution depending on time and season will lead to a smooth downstream runoff and reduce the variation amplitude and seasonal changes of river runoff, namely making the river runoff stable. As is known to all, the hydrological factors play an important role in the formation and development of marsh wetland. Under natural conditions, the hydrologic conditions of wetland will have seasonal changes and will be affected by river changes. However, the upstream dams combining with impoundment and water diversion will eliminate the flood, which will reduce the supply of sediment and nutrient substances that are necessary for wetland. Due to lack of nutrition substances, the wetland will gradually become infertile. Therefore, the plants and creatures living in the wetland will gradually reduce and the wetland also will shrink. In some cases, the shrink of wetland even will affect the food chain of aquatic organisms, leading to disorder of ecological balance and decreasing biodiversity. Take the three gorges reservoir region of Yangtze river as an example. Relevant data is shown in TABLE 1.

Wetland is an important regulator of water resource system. The boundary water-exchanging between wetland and waters is very active, which plays a positive role in maintaining regional water balance. As the wetland can keep a large amount of water, it can ease the changing process of hydrological conditions of relevant rivers. In contrast, decreasing wetlands will produce a series of serious consequences. The catastrophic flood happening in the Yangtze river basin, the Nenjiang river basin, and the Songhua river basin in 1988 was due to the sharply decrease of wetland and the degradation of the function of wetland.

TABLE 1 : Take the three gorges reservoir region of Yangtze river

Layer number	Layer name	Elements	Geometric features	Layer number	Layer name	Elements	Geometric features
1	DXPT	elevation point	Point	18	SDZY80s	80s current situation of wetland resources	Polygon
2	DXPL	contour line	Line	19	SDZY99	99 current situation of wetland resources	Polygon
3	DZTL	characteristic line	Line	20	ZBGD80s	80s vegetation coverage	Polygon
4	SXPY	watershed surface	Polygon	21	ZBGD99	99 vegetation coverage	Polygon
5	SXPL	watershed line	Line	22	GCQS80s	80s engineering erosion and gravity erosion	Polygon
6	JUMD	settlement place	Polygon	23	GCQS99	99 engineering erosion and gravity erosion	Polygon
7	ANNO	annotation	Point	24	TRQS80s	80s soil erosion	Grid
8	ROAD	road	Line	25	TRQS99	99 soil erosion	Grid
9	DEM	digital elevation model	Grid	26	LYJX	boundary of small watershed	Grid
10	PODU	gradient partition	Grid	27	SBCS	measures of conserving water and soil	Grid
11	XZQH	administrative boundaries	Polygon	28	TDBH	changes of land utilization	Grid
12	TDLY80s	80s current situation of land utilization	Polygon	29	SLBH	changes of forest resources	Grid
13	TDLU99	99 current situation of land utilization	Polygon	30	CDBH	changes of grassland resources	Grid
14	SLZY80s	80s current situation of forest resources	Polygon	31	SDBH	changes of wetland resources	Grid
15	SLZY99	99 current situation of forest resources	Polygon	32	LXBH	changes of type of soil erosion	Grid
16	CDZY80s	80s current situation of grassland resources	Polygon	33	QDBH	changes of soil erosion intensity	Grid
17	CDZY99	99 current situation of grassland resources	Polygon	34	IMAGE	fusion image	Tif

WATER CONSERVANCY PROJECTS WILL LEAD TO SALT-WATER ENCROACHMENT

The salinity of water depends on changes of runoff. For example, during the dry season, the salinity of water in estuary will be higher, and during the flood season, the salinity will be lower. If the river has an estuary, then the changes of sea runoff will also affect the concentration of salt. When the river runoff decreases, the seawater will sail upstream along the river, which will pollute the river water and groundwater, reduce the amount of freshwater resources in estuary, and eventually affect production or daily life. Therefore, in the regions where the water conservancy projects have an impact on impoundment and water diversion of reservoirs and on water consumption of large part of cities along the river, salt water will encroach the estuary, salinize underground water and the soil of bottomland, thus reducing the amount of underground drinking water and change the estuarine ecosystem. The following two examples respectively are the influences of the Farakka Dam and the Three Gorges Dam.

India built the Farakka Dam at the Ganges River. Since the Dam worked, relative seasonal decrease of river runoff continuously appeared, which brought bad influences on the downstream Bangladesh. The problem of land salinization kept aggravating to the extend that in the mid 1990s, the area of salinized land due to existence of Farakka Dam continued to increase from 0.35 million hectares before building the dam to 0.89 million hectares.

And for another case, although the Yangtze River's annual water discharge entering into the sea has not changed on the whole, its seasonal runoff has changed. The system structure of ecological engineering is as shown in Figure 3. The water-salt balance in the estuary has greatly changed. For example, during the wet season, the reservoir will store water, therefore the seasonal river runoff will decrease, the salt tide will develop along the upstream river. The time of salt-water encroachment will be advanced and its duration will also be prolonged, thus affecting the desalting process of the land in these regions. However, in Spring, the river runoff will increase. The water level of the river will increase and the water level of downstream river will also increase, which will aggravate the conditions for the soil to drain away water and eliminate salt.

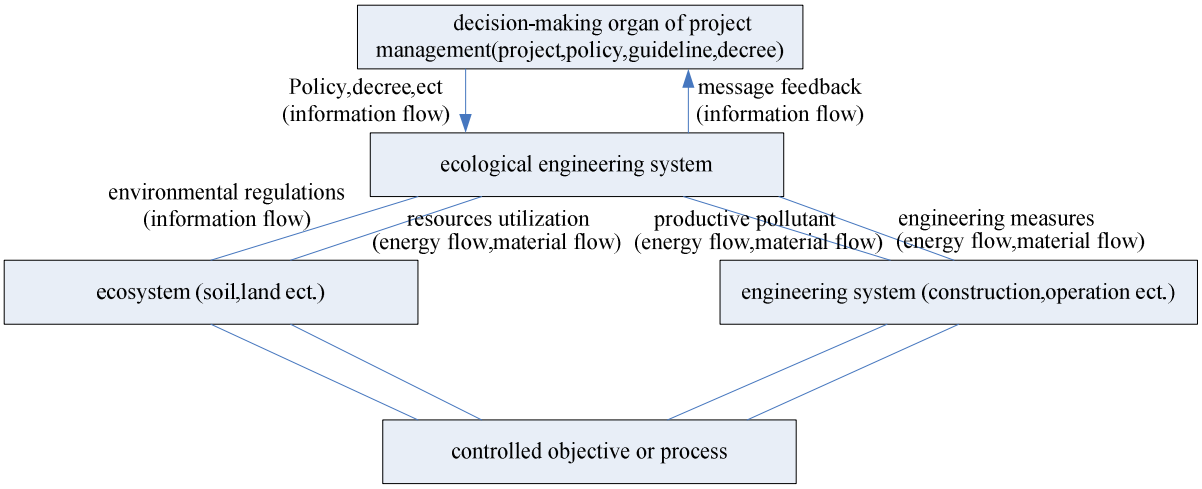

Figure 3 : System structure of ecological engineering

RELATIONSHIP BETWEEN WATER CONSERVANCY PROJECTS AND COASTAL EROSION

The substances carried by river water begin to deposit in estuary and these sediment eventually form the delta. During this process, the sediment continuously carried by river water form coastal landscape and stable coastline. If the upstream water conservancy projects retain and diverse the water, the sediment carried by river water will be reduced. And because a large part of the sediments is silt, the decreasing sediments will reduce the capacity of sediment supply and sedimentation of coastline. Besides, the original delta will also be affected and be significantly reduced as a possible result. The specific situation is shown in Figure 4.

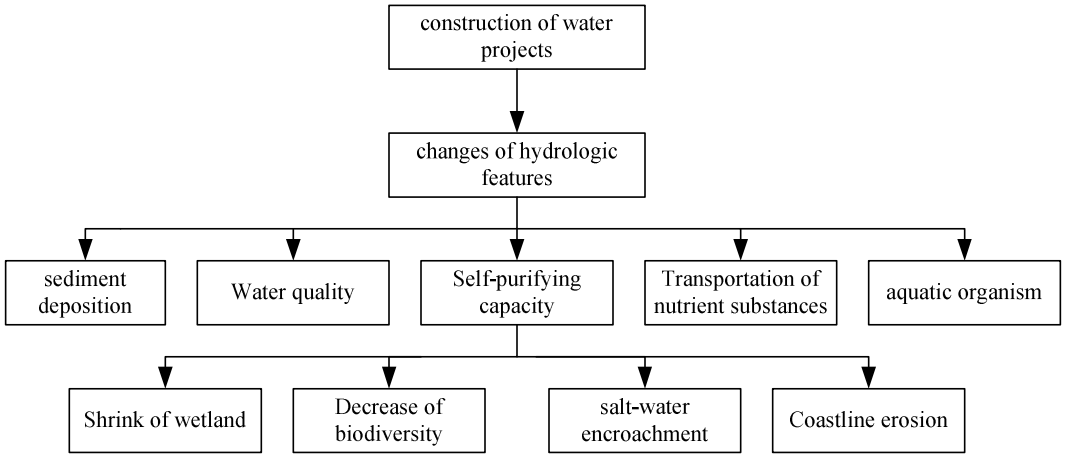

Figure 4 : Impact of water conservancy projects on surroundings

Besides, the sea level rise due to greenhouse effect is another main cause of coastal erosion. For example, the formation of the Nile delta is slow deposition, but since 1868, it gradually turned into the erosion type. After the the

completion of the Aswan Dam in 1970, the amount of sediment carried by the river water significantly reduced,especially the silt, which leaded to further serious erosion of estuarine coast. The Nile delta shrunk faster and faster. Since the 1990s, the formation of estuary coast of the Yellow River which originally was based on slow deposition also turned into the erosion type with the rapidly reduction of downstream runoff and sediment. Moreover, with the completion and operation of the Xiaolangdi reservoir, the decrease of sediment will also become inevitable trend. The coastline erosion will be very serious without taking any measures.

CONCLUSION

In general, the implementation of water conservancy projects will cause the changes of the hydrological conditions of estuary, which will affect the sediment, concentration of nutrient substances, water quality, and self-purifying capacity of water. These changes will also affect the biological habitats of estuary creatures, thus changing the structure, composition, distribution characteristics of biological community. In China, before starting one water project construction, the impact of water project on the environment will be analyzed and inferred. Take the construction of the Three Gorges Dam as an example. Since the 1950s, the feasibility of Three Gorges project has been discussing. During the discussion, relevant geology, geomorphology, hydrology, soil and aquatic organisms, fish resources, lakes and estuary environment were all taken into account with a large amount of data obtained through investigation and research. The water project has a long-term and slow impact on ecological environment and that process is extremely complicate.

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