Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 13 (17): 3394-3399, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.3394.3399

Three Gorges Project's Impact on the Water Resource and Environment of Yangtze River

[1]Li Zexin, [2]Wang Rong, [1]Zhou Zili and [1]Luo Xian Zheng
[1]Institute of Architecture and Urban Planning, Chongqing University, Chongqing, 400045, China
[2]Institute of Resource and Environment, Yunnan Agriculture University, Kunming, 650201, China

Abstract: The three gorges project's running and its water resource's protecting and utilization are related to the urban and Ural entironment and people's fitness of the Yangtze River. Key issues about water resource such as reservoir areas' water quality, relation between rivers and lakes, ground water are the hot topics that being broadly watched. This study put forward the engineering and zoology measures on water resource environment's protecting and reasonable utilization after the analysis of the three gorges reservoir areas and the Yangtze River.

Keywords: Three gorges reservoir project, water resource and environment

INTRODUCTION

Yangtze is one of the rivers which have the most abundant water resource in the world. Using the water resource rationally is significant to the human being's sustainable development. The three gorges reservoir project, from starting to working, is always the focus of all walks of life. Water quality's variation of mainstream and tributary after the formation of reservoir areas is one of the most sensitive themes. Three years after the three gorges reservoir project began to work, benefits on flood defend, electricity generation and shipping have been gradually appeared, so the water resource of reservoir, mainstream and tributary begin to get more and more attention from government, the masses and experts.

THREE GORGES PROJECT'S IMPACT ON THE WATER RESOURCE AND ENVIRONMENT OF YANGTZE RIVER'S UPSTREAM

The water storage ability of three gorges reservoir project is 135 m in 2003, 156 m in 2006 and up to 175 m after September 2008 (Li, 2008). Yangtze become to be the reservoir in river way form from natural river way, there some hydrology elements have notable changes, such as water level's raising, reservoir capacity's increasing and the velocity's dropping and the water environment of reservoir areas' mainstream and tributary of Yangtze river has the responding change which inflect the water resource environment directly. Whether the reservoir manage can be optimized, is the main problem that experts and scholars concerned. Since the three gorges reservoir project has the 175 m water storage for 3 years, upstream water resource environment have appeared many types.

Water quality in mainstream become well, while in tributary that affected by water storage and the declining river section become complex: According to the monitor data of the three gorges reservoir areas' water quality published by "Yangtze the three gorges reservoir monitor bulletin on zoology and environment" water quality along the mainstream in middle and downstream of Yangtze is up to or be superior to III class; water quality in the return-water declining river section (Fengdu and Chongqing city) would turn better in water storage period (December to March of the next year), while in other times it still turn better but not obvious. Compared with former, velocity in return-water river section of the tributaries such as Wu Jiang, PengXi River, DaNing River, which are affected by the dam, has slow down or even become still and part of the water environment become more and more complex. The reasons why water quality in main part of the stream changed along the time are that reservoir's self-clean ability strengthens because of the magnification of reservoir capacity and that pollution discharge system in reservoir area has functions. When the flood coming, a large amount of pollutions come with the flood, which make the water become worse.

In terms of water environment of three gorges,water condition of town and country in the middle and downstream of Yangtze River, get improvement no matter withered water period or high flow period. Water level decline section[1] also influences the water quality.

Corresponding Author: Li Zexin, Institute of Architecture and Urban Planning, Chongqing University, Chongqing, 400045, China

[1]The decline section is due to the difference of the water level. In terms of Yangtze River, it always refer to the section between Fengdu and Chongqing city; decline sections always along the reservoir coastwise with its altitude between 154 to 145 m and its scope depends on the horizontal slope.

Along the construction of the power stations[2] in the mainstream and the first level tributary Jialing River and Wu River in Yangtze upstream, the bad effect on water that three gorges project caused will be remised appropriately.

River property has changed, part of the river branch appear "bloom": Monitoring shows that, after the three gorges reservoir 175 m water storage, some part of water in tributary rivers with small flow such as PengXi River, TangXi River, DaNing River in middle and lower reaches of rivers appear "bloom" phenomenon. 2008, March to October, a monitoring results show that, water percentage range in the state of the eutrophication in Yangtze river main tributaries, is 14.6~28.1, 20.1% one month average, which has an increase of 4.2% compared with last year. Influenced by water storage, the tributaries of the return-water eutrophication is significantly heavier than the common space. It is mainly because reservoir water keeps a higher level for a long time and flow velocity is small in water storage period, that the water retention time was greatly extended. Because nutrient concentration is not high in return-water period of tributaries, so the large number of algae breeding is due to the river hydrological conditions' change:

- "City hanging in the air" and "waterfall", is the questions need long-term consideration in city construction, water environmental protection and utilization in reservoir areas

At present, large scale cities choose their construction land at an altitude of 180 m above the elevation. Because most of the city is located in the mountains, construction land is higher than 175 m water level, like the county YunYang whose altitude range from 180 to 350 m or so and the WuShan county whose altitude is from 180 to 400 m or so. The construction of this kind of "city hanging in the air" caused the inconvenience use of water resource: On one hand, cities' height difference is too large that people must use multilevel water supply which made the water supply more and more difficult; On the other hand, some day, when Chinese descendants no longer need three gorges hydropower station or three gorges hydropower station is at the end of its life, these cities will be the "city hanging in the air", away from the Yangtze river natural river level. In that time, these cities will choose which way to develop, no one knows. In addition, the city have many dewatering holes at present, when at the water fall background, the dewatering holes will be the waterfall, this also is the issue that needs consideration in water environment protecting and utilization in three gorges reservoir areas.

Reasons and countermeasures

Reasons analysis: Flowing form change affects water quality. On the bad hand, along with the three gorges reservoir water level rising, the velocity of reservoir areas decreases and water quality deteriorated. According to relevant material, the Yangtze river natural riverway average section velocity is 0.85 m sec^{-1} in withered water period, while after water storage the section average flow velocity declined to 0.17 m sec^{-1}. Especially in the deep water in the front of the dam, the section average flow velocity is just 0.04 m sec^{-1} or so after reservoir built. When flow velocity slow down, the organic pollutants' self-decomposition rate and atmospheric complex oxygen rate are significantly weakened which caused water quality's deterioration. On the good hand, owing to the increasing capacity and the extend time that pollutants retain in the reservoir area, self-clean gross is much large than before, so the organic pollutant concentration still drop down compared with before.

Emissions increase affects water quality: The upper Yangtze River region's social economy is relatively backward before the three gorges project's construction. The three gorges project brings rapid development of urbanization (Table 1). Along with the development of industry and agriculture, solid waste, industrial waste water and agricultural production the pollutants increase rapidly which has more and more influence on water quality. Different from the other domestic large reservoir, the three gorges reservoir area's shipping developed rapidly and ship pollutants increasingly aggravated. Marine pollution with many characteristics such as flowing, universal, line length, scattered, become the important pollution sources of rivers. At present the number of mainstream ships has greatly increased. Ship sewage, live sewage and garbage, ship exhaust is directly dropping into the water, which directly impacts the water quality.

Countermeasures: Moderate control on upstream urban population scale, make a scientific strategic decision on the urbanization development level and way. Since the development of the western region and Chongqing directly under the jurisdiction of center right, the upper Yangtze river region begin to grow rapidly and this is the inevitable result of narrowing the gap and gaining common rich. Over the past 20 years, the related counties in three gorges reservoir area have a rapid development;

[2]Hydroelectric power station are developed gradually, the power station under construction are along the mainstream in Chongqing city such as little south sea, WuluoDu, BaiHeTan, while HeChuan CaoJie, WuSheng, CangXi power station along JiaLiang River and PengShui power station along WuJiang River. This way of construction can remit the environmental impact in certain degree.

Table 1: Increase and decrease of the water fall's impact on Dongting River[3] (LONG, Z., 2009)

Time		Increase and decrease of the water fall and water level	Impact on water and zoology environment of dongting river
Withered water period	December~March of the next year	Increase of water fall,February the most, water level raised by 0.22 m in Dongting river and the northeast of south Dongting river	Water level increase, influence the food of birds, destroy their lodge land be good for the lives live in water
	April	Decrease of water fall, a little decrease of water level	be favorable to tai grass
	May	Increase of water fall, water level raised by 0. 21-0. 58 m, tai grass in low altitude and reed in high level, flood 20-30 days in advance	The vigorous time for ludi grass, flood in advance reduce the life by 25~30% ;and make the life in waters waters failure
Flood period	June~September	Decrease of water fall, a little decrease of water level	No obvious impact
Water filling period	October~ November	Decrease of water fall, an obvious decrease of water level,1.4-1. 6 m in east Dongting river, 0. 59-1. 2 m in south Dongting river and 0. 63-0.75 m in west Dongting river, the lowest riverbank appeared 1 month advanced	Be beneficial to grass living in low areas; but the excessive fall water level will cause the grass die in in advance

urbanization rate has an annual increase of 1~2%. A large rural population goes into the city. Because the urban sewage treatment level is higher than rural areas, the urbanization level increase has a positive affection on the water resources protection. But we also should see that the increasing urban population scale can cause many environmental problems such as the hard ground increasing, rain water runoff time turning shorter. At the same time, water environment in three gorges reservoir area will be damaged if the city (town) sewage treatment is short of the standards; So, the main city's appropriate scale control should attracted more attention; In terms of the main river hydropower development on earth, there is no such as the Yangtze river three gorges hydropower station in whose upstream having metropolis such as Chongqing, Chengdu, especially in whose tail there is Chongqing main city with 6 million city population, urbanization rate 70%. Just as of urbanization in reservoir areas, it is of great significance for three gorges reservoir areas environment and water resources protection to take the industry, social urbanization way.

Strengthen the sewage management, control city sewage strictly and pay more attention to the rural pollution sources. The sewage discharge that reached standards, is an important project for the three gorges reservoir water environment. At present, in the upper reservoir areas the medium-sized city sewage treatment is enough, while small city (town) and the rural sewage treatment and discharge need more attention where the wastewater treatment facility is backward and the sewage treatment is very low and even never have treatment. In the long run, it will cause irreparable damage on the water resources environment. For reservoir and the small cities, we should strengthen wastewater collection and treatment facilities of the investment; while for small towns and rural areas, we should gradually construct sewage treatment facilities. If it is said that construction of water conservancy facilities in new China 1960-1970s established the stable solid foundation for the development of the agriculture today. Then the author believes that, the construction of sanitation facilities and sewage treatment facilities in small cities and rural will be the important infrastructure future for China's long-term stable development.

THREE GORGES PROJECT'S IMPACT ON THE WATER RESOURCE AND ENVIRONMENT OF YANGTZE RIVER'S MIDDLE AND DOWNSTREAM

According to the three gorges reservoir 175 m water storage scheduling rules, in withered water period which begin at December to May of the next year, three gorges reservoir should make room for flood control storage, so the discharging flow is 1000~2000 $m^3 sec^{-1}$ more than before and the front dam water level fall to the flood control limit 145 m; During flood season that from June to September, the front dam water level maintain at 145 m; In the end of the flood season, October, reservoir achieve the normal storage level of 175 m which can last until November. In this process, the average discharge flow is 10000 $m^3 sec^{-1}$ which reduces by near 3000~6000 $m^3 sec^{-1}$ and is 40% less than before. The current reservoir operation scheduling model has both good and bad influence on water resources and environment of the middle and downstream of Yangtze, which is mainly embodied in the following aspects:

- The river-lake relationship changed due to reservoir which affect the water resources environment of river and lake

The completion of three gorges project has influence on the river-lake relationship (Dongting Lake, Poyang Lake), especially the middle of Dongting Lake area which

[3]Three entrances are SongCi, TaiPing and OuChi of Yangtze. Yangtze river goes into Dongting Lake through these entrances and return to Yangtze river through chenglingji. Four waters indicate Xiangjiang River, Zijiang River, Ruanshui River, Lishui River.

is showing up in the variation of erosion and the falling water levels. At present Dongting Lake is the natural lakes which keeps the connectivity and has the biggest water exchange water with the Yangtze river. Its water is mainly coming from three entrances and four waters[3]; Sand is mainly coming from three entrances. The construction and operation of the three gorges reservoir caused a huge change on the relationship between Yangtze River and Dongting Lake. From the general level, the three gorges project has more good than bad impact on Dongting Lake. From the flood control angel, the three gorges project will greatly relieve Dongting Lake's flood defense pressure, because after completion and operation of the three gorges project flood divided into the middle and downstream of Yangtze River was declined which created a favorable condition to tackle the Dongting Lake flooding that last for a century. Look from the sediment deposition, the sediment entering Dongting Lake from Yangtze River is falling sharply after the three gorges project, so the deposit quantity will radically reduce which is very advantageous for both maintaining Dongting Lake's storage capacity and extending the life of Dongting Lake.

Reservoir operation is conducive to reducing the sediment of Dongting Lake which is favorable to the surrounding water resource environment: Because waters go in Dongting Lake with large amounts of sediment, Dongting Lake is in the deposed condition for a long time. After impoundment of the three gorges reservoir, sediments that come from Jingjiang to enter Dongting Lake reduced substantially. Therefore, the construction of three gorges reservoir play an important role in easing the Dongting Lake sedimentation speed, reducing sludge.

Because of coming water's reduction from Yangtze River in water filling period, Dongting Lake area's water shortage would be very severe in case of dry season: In recent years, part of Dongting Lake area is serious droughty with the autumn drought most serious and its main reason is the upstream rivers water reduction. Effected by the factors such as downstream cutting corners, the mainstream reservoirs and other factors, the water percentage that Yangtze River divid into Dongting Lake is down to less than 12% after 2000 from 30% in the 1950s, drought days keep increasing, water keep decreasing in autumn/winter season. The three gorges project makes this trend more evident, water diversion ratio will reduce in the further days and the shortage of water resources will be more serious in dry season.

Upstream sediment, water decreasing and downstream aggravate rush caused Dongting Lake's water level decline and made an influence to the water resources utilization of surrounding area of the lake area: The three gorges reservoir areas' water release brushes the riverbank year by year, water into Dongting Lake has the responding reduction. The increasing flow from three gorges project cannot meet the need of the water flow into lake. So, in recent years recession of three river system that Yangtze river goes into Dongting Lake is very clear. Department of water resources monitoring showed that the average water yield into Dongting Lake is 150 billion cubic meters in early 1950s and it had decreased to 62.1 billion cubic meters in 1990 to 1998 years. After the impoundment of the three gorges reservoir, water quantity that Yangtze River flow into the lake reduced more. The total amount of water that the Yangtze River flow in the lake is 1.53 billion cubic meters between September 20 and October 31 in 2006, which reduced by 93% compared with average amount in the same period. In October 1972, the most severe drought period in the History, Yangtze River's average water flow into the lake is 2114 m^3 sec^{-1}, but in October 2006, it was only a quarter of 1972. On September15, 2009, three gorges project began to carry out the experimental water storage, it keep the 30% of the coming water which reduce the downstream water. In the first ten-day period of October, three gorge's warehousing flow is 13000 m^3 sec^{-1} and outbound flow is 7000 m^3 sec^{-1} which makes the water into the lake reduced more. The water level decline also because of the extra factors such as the falling outlet water levels in Dongting entrance and the fast flow[2] (Wang, 2010).

Influence on water resources environment of Poyang Lake at downstream: In 2007, the whole dry season of Poyang Lake advances more 70 days than normal year and extend more than 50 days, due to various factors. The Lake District's low water level (7~8 m) lasts more than 90 days. Changes of hydrological elements in the Lake District make the changes of water resources development and utilization. The water level will reduce for 1.5-2.0 m when three gorges began to store water in October every year. The water level decrease mostly in early November than normal year. And because of the low level of water entrance, it is much easy to form withered water period which can lasts for 2 or 3 months. At the same time, because of the falling of water entrance levels, the amount of water out of the lake increase about more than 30 billion cubic meters, which directly led to the lake district level fall, water storage reduced. On the other hand, in the dry season the water flow is more than nature situation which

can give appropriate compensation to water entrance level. It has a positive effect on the protection of water resources.

Overall, there are both advantages and disadvantages about three gorges project on affecting water resource environment of the two great lakes in middle, lower reaches and mainstream and tributary. Here are the advantages: it can keep water to protect the middle and downstream from flood, also can supply water for downstream in the dry season (December on March in the next year). The disadvantages are that the amount of discharge declined in water filling period (10 to 11 months), causing the lake of water in downstream. When facing the Yangtze River basin drought, the outbound water yield will be affected, so the falling of water level is inevitable. There is an embarrassing situation now many water storages are facing: no water can be put out from upstream when water is required in the downstream.

Changes of downstream groundwater operation and water level have influences on urban and rural water resources environment in middle and downstream Yangtze plain: The water quality and groundwater level are the important factors that influence both urban and rural areas water environment in the middle and downstream of Yangtze River. Dynamic balance of the existing surface water and groundwater is the continuously ecological process for thousands of years in the middle and downstream of Yangtze plain. The three gorges reservoir's operation changes the Yangtze River natural runoff process of under-dam areas in a certain extent, thus to influence the Yangtze River groundwater change. This process can be divided into three sections: Water flow decrease in October to November when reservoir store water lead the groundwater level falls, but it last a shorter time than natural river in this season; In the withered-water period (January to May) water flow increase and the groundwater level rises; In flood season (June to September) water flow change is small so groundwater level get little impact (Zhang *et al*., 2009).

Before the three gorges reservoir, from May to November the river supply water to underground and in the rest season the Yangtze River play a role as the groundwater container in the middle and lower reaches. Groundwater and river water exchange seasonally, this is important not only for the Yangtze River's water purification, but also for adding nutrients to the Yangtze River and the maintaining of river ecosystem balance. After the operation of three gorges reservoir, water flow increases in dry season and this causes river water level rise which will block the groundwater discharge to Yangtze River; Take LongKou observation profile for example, if the Yangtze water level increased for 1m, the confined water level drive up by 0.25~1.0 m within the distance 0-1 km area, 0.05~0.25 m within 1~4 km location and 0.05~0.10 m with 4 to 9 km location (He and Cai, 1999). After the operation of the three gorges reservoir, there is a notable change on the water supply, the water discharge and natural ecological process, the extent of the water level change is shrunk in the middle and lower Yangtze. It's certain that it has the negative influence on the middle and lower Yangtze surface water and groundwater resources environment.

Countermeasures and proposals: Deal with the changed river-lake relationship properly after three gorges project's water storage. Complex river-lake relation is a long-term controversial subject. Project implementation makes it more difficult to predict so this kind of project is hard to make decision and to implement. We should excavate the potential of the three gorges reservoir from the angle of Yangtze River water resource utilization and protection.

Optimize operation of reservoirs: In 2011, follow the state council's requirements "about the three gorges follow-up work planning of official reply", we should expand comprehensive benefit of the three gorges project from the main direction of development such as making flood resources, optimizing reservoir operation, expanding the water supply benefit. During the 2012 National People's Congress, Chongqing delegation reported that with objective trend of flood control change and the improvement of scientific prediction capability on water rainfall regime, the three gorges reservoir have further optimization space: On the condition that there is a 2.639 billion cubic meters flood defense capacity in upstream, the limit water level can raised to 150 m from the beginning of 2012; and to 155 m after the completion of the XiLuoDu and XiangJiaBa reservoir in 2015 and gradually to 160 m depending on the circumstances. Raising the flood limit water level of the three gorges reservoir to 160 m can increase the three gorges reservoir water storage, which is beneficial to the middle and lower reaches in ecological water supply and to continued water supply for the north drought areas. This reflects the optimizing from theory to practice of the original design scheme of the three gorges project (145 to 175 m) after many years operation. Of course, the specific optimization scheme needs further analysis, including the running time optimization, water level optimization and so on. Make a comprehensive demonstration and a scientific decision from flood control, water safety of water resource, the city construction and so on.

CONCLUSION

The three gorges project, realizing the "high gorge and flat lake" vision, gain the benefits of flood control, power generation, navigation and consider the balanced development of the Yangtze River. In upstream areas, many new towns have been built up at the cost of millions of immigrants; in middle and lower reaches, people gain benefit at flood prevention, but must face the water shortages at the same time. In the long run, three gorges project takes the history responsibilities and needs comprehensive scientific evaluation and optimizing from society, economy, culture and ecological aspects; The way from beginning to vista needs continuous summarize, prosper the good while remove the bad.

REFERENCES

He, B. and S. Cai, 1999. The three-gorge project and dynamics of shallow confined water in the area of the middle reaches of Yangtze river. Resour. Enuiron. Yangtze Basin, 8: 95-100.

Li, Z., 2008. The three gorges reservoir area of residential environment construction of integrated traffic system construction. Southeast University Press, Nanjing, China.

Long, Z.H., X.Z. Huang and Y.H. Ding, 2009. Look at the water resources development management countermeasures from Dongting Lake ecological environment problems. Water Conservancy Dev., 3: 13-18.

Wang, H., 2010. Alert Dongting Lake water crisis. Life World, 3: 38-41.

Zhang, H., S. Chen, G. Zhang and X. Xiang, 2009. The effect of three gorges project on groundwater level and soil gleization in Honghu Region. Syst. Sci. Comprehen. Stud. Agric., 3: 317-322.