Article, Published Version

Sitharam, Thallak G.

Envisaging a fresh water reservoir in the arabian sea to impund the flood waters of Netravati River

Hydrolink

ENVISAGING A FRESH WATER RESERVOIR IN THE ARABIAN SEA TO IMPOUND THE FLOOD WATERS OF NETRAVATI RIVER

BY THALLAK. G. SITHARAM

A solution to the water problem in parts of India along the coast is to conserve the abundant monsoon water bounty, store it in coastal reservoirs, and use this water in areas which have occasional inadequate rainfall, or are known to be drought-prone, or in those times of the year when water supplies become scarce. Coastal reservoirs are an innovative concept, which offers the potential to store the flood waters of a river near the point where it flows into the sea and meet the water requirements of water starved cities [1]. Mangaluru city, in Karnataka state, India is blessed with the river Netravati, which carries a great quantity of water during the monsoon and ends up in the sea. The annual runoff at the mouth of the Netravati River is estimated to be 388 thousand cubic meters (TMC). Just 3% of this would be sufficient to meet the present water shortfall of Mangaluru city and Bangalore the capital city of Karnataka. This article describes a feasibility study executed for the Bangalore Water Supply and Sewerage Board (BWSSB), Bangalore.

The use of coastal fresh water reservoirs is a new emerging concept of storing flood water close to the shoreline [2]. Coastal reservoirs can be constructed in shallow waters at appropriate locations close to the river mouth along with a barrage at one or two ends. Sea walls or breakwaters with some modifications along with new and sustainable construction technologies are used to construct such coastal reservoirs. Many countries like China, Singapore, Hong Kong, The Netherlands, India, South Korea, Japan, and the United Kingdom have already constructed such reservoirs to augment water supply and serve other purposes [2].

Mangaluru, a coastal city, situated between the Arabian Sea and the mountain ranges of the Western Ghats, is the chief port city of Karnataka. It is the largest city in the Dakshina Kannada district of Karnataka and is one of the most cosmopolitan non-metro cities of India. Mangaluru is a moderately earthquake-prone urban center and is categorised under the Seismic III Zone in the seismic zonation map of India. Mangaluru city had a population of 0.485 million in the 2011 census of India. The city is located at the confluence of the Netravati and Gurupura rivers, and has an average elevation of 22 m above mean sea level. The rivers form an estuary at the south-western region of the city and then discharge into the Arabian Sea.

A fresh water reservoir near the coast would bring a positive transformation in coastal Mangaluru in terms of cleanliness, living standards of the people, human resource development and livelihoods. The envisaged coastal reservoir project scheme in Mangaluru comprises mainly two steps; first, the

Figure 1. Artist's view of Mangaluru Coast near the Netravati estuary, after the construction of the coastal reservoir

construction of a dyke in the Arabian Sea, and, second, the process of natural replacement of salty water in the reservoir by rainwater and surface runoff. Considering the tidal variations and wave heights, the dyke must be designed to separate fresh water from the salty waters of the Arabian Sea.

Course of the Netravati River

Figure 2 shows the Netravati River basin in the state of Karnataka. The Netravati River originates in the Western Ghats in the Bangrabalike forest Valley in the Yellaner Ghats of the Kudremukha range in Karnataka. The Netravati is joined by the Kumaradhara River near the Uppinangadi village. The Kumaradhara River also originates in the Western Ghats in the Subramanya range. After it flows through Uppinangadi, it arrives in the city of Mangaluru. After merging with the Kumaradhara River, the Netravati then ends in the Arabian Sea. As shown in Figure 3, this river drains a large quantity of water into the Arabian Sea every year close to Mangalore city.

Average Annual Rainfall and Runoff in the Netravati Basin

The average annual runoff in the Netravati Basin during 1989-2013 was 388.5 TMC with a standard deviation of 78 TMC, and a maximum of 528.34 TMC in 2007-2008 The average annual rainfall in the Netravati Basin over the decade 2003-2013 was 3922.5 mm with a standard deviation of 383 mm and a maximum of 4427.8 mm in 2009-2010. No major variation in the rainfall has been experienced in the last decade. The sediment load is negligible and hence silting in the proposed coastal reservoir should not be a major problem.

Geotechnical considerations

Geotechnical investigations carried out at the coast off the Ullal beach near Mangaluru suggested that no extreme geotechnical challenges exist and that construction of the proposed coastal reservoir can be undertaken. Two exploratory boreholes at each of two sites off Ullal beach at a water depth not more than 6.5 m were drilled. The soils at these sites consist of clayey medium dense sand in the top 1.5 m followed by clay up to 3 m. Below 3 m, dense to very dense clayey sand was encountered up to 9m deep followed by poorly graded dense sand with pockets of clay. Beyond 20 m depth, a thick clay layer along with dense sand is present. The settlement (immediate and long term) of the proposed coastal reservoir dyke is expected be about 300 mm to a meter.

A detailed integrated site survey comprising of a geophysical investigation (bathymetry, sidescan sonar and sub-bottom profile) and a geotechnical investigation (borings, in-situ testing and laboratory testing) shall be undertaken in order to develop an appropriate geological model for the site of the proposed coastal reservoir.

Inferences and Feasibility Implications

It is imperative that a small percentage of waters of the Netravati is more than sufficient to cater for the water requirements of Mangaluru. The data for the last few decades suggest that there is no scarcity of water in the Netravati River, but the city faces water shortages. This necessitates revisiting the current water storage strategies and exploring new ways to tap at least a small amount of the river flow to meet the water demand. The concept of a coastal reservoir seems to be the best solution to meet future water demand in Mangaluru. The feasibility implications are summarized below.

The average annual runoff in the Netravati basin is 388.5 TMC. According to the Bangalore Water Supply and Sewerage Board (BWSSB), the shortfall in demand in Bangalore for 2051 will be 26.16 TMC which is 7% of the average annual runoff in the basin. In 2021, the shortfall in demand is estimated to be only, 8 TMC which is just 2.1 % of the total basin runoff.

Silting in the proposed coastal reservoir is unlikely as the average annual sediment load in the Netravati River is 0.04 TMC.

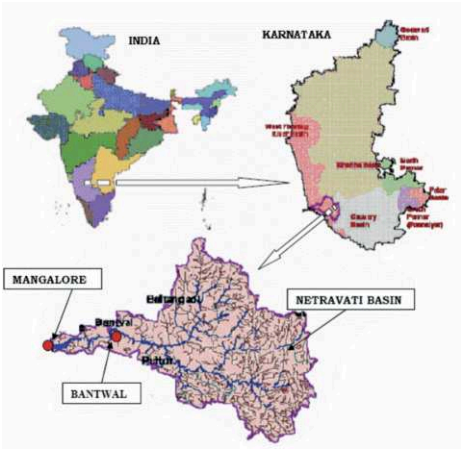

Figure 2. Netravati River basin

The water quality parameters in the Netravati River are within safe drinking water levels, which means that the water can be used directly without any major treatment.

The creation of the coastal reservoir may affect marine fishing in the area, but it will open up the possibility of freshwater fishing. A fishing wharf can be established along the dike of the coastal reservoir which will provide deep water fishing options for the fishermen and pave the way for Mangaluru to become a large exporter of both marine and fresh water fishes.

The seismic hazard in the area is very marginal and hence the site is safe in terms of seismicity. The coastal reservoir can act as a safety structure to protect the coastal region from tsunami hazards.

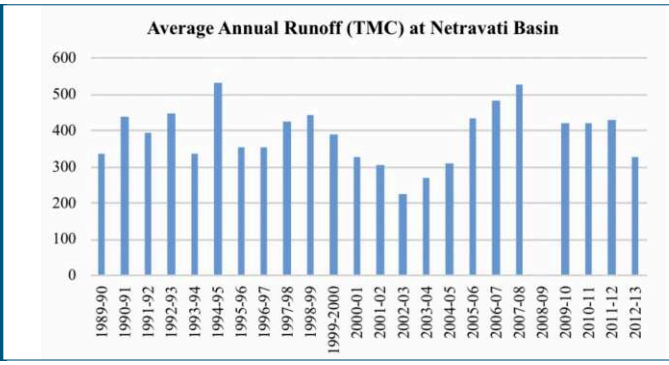

Figure 3. Average Annual Runoff at Netravati basin [3]

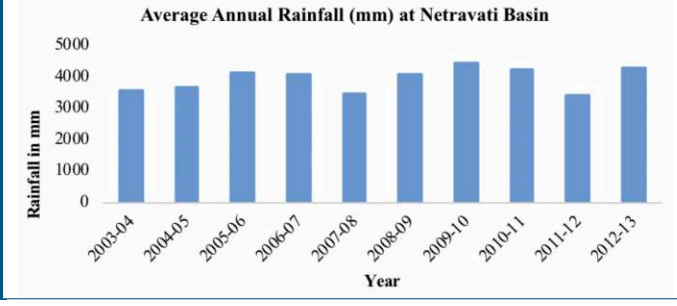

Figure 4. Average Annual Rainfall in Netravati basin [3]

Renewable energy can be used for pumping, lighting and other energy requirements. Consultation with and input from renewable energy developers would support the planning phase of the project to achieve cost effective renewable energy generation.

We recommend two phases for the construction of the coastal reservoir. Figure 1 shows the proposed reservoirs (phase 1 and Phase 2) along with Coastal Regulation zone (CRZ) of 500 m. Good quality water from the Netravati and Gurupura rivers can be diverted into these proposed coastal reservoirs during the monsoon months. Smaller water quantities during non-monsoon months could also be diverted after ascertaining that the quality of the water is good. In Phase 2 the proposed coastal reservoir will save the Ullal beach, which is endangered due to erosion. The length of this coastal reservoir is about 8.3 km starting from the river mouth to the South of Mangaluru Port with a width of 6 km. The coastal reservoir will not affect the built-up area. The assessment of land use in this area indicates that the built-up area is limited, while the vegetation cover is more extensive. Also, because the construction of the fresh water reservoir will cause a reduction in the salinity of the water, its effect on the vegetation must be pre-assessed and analyzed. The construction phase and later the maintenance of the coastal reservoir will create employment opportunities for the local people. As part of the sustainable city development plan, rehabilitation of the areas around both the Gurupura and the Netravati River are recommended as part of the project component in order to change the existing landscape making Mangaluru an attractive, clean and beautiful water front City (see Figure 1).

Prof. Dr. T.G. Sitharam is a KSIIDC Chair Professor in the area of Energy and Mechanical Sciences and Senior Professor at the Department of Civil Engineering, Indian Institute of Science, Bangalore (IISc). He was former founding Chairman of the Center for Infrastructure, Sustainable Transport and Urban Planning (CiSTUP) at IISc. Over the last 25 years, he has developed innovative technologies in the area of sustainable civil engineering and geotechnical applications, leading to about 500 technical papers, ten books, four patents, 100 consulting projects and two startup companies. He has guided 30 doctoral students. He is the chief editor of two international journals in his areas of research and founder President of the International Association for Coastal Reservoir Research (IACRR).

Acknowledgment

The work and the ideas described in this article are the product of contributions of many people including Dr. Sreevalsa K, Professor Subba Rao, Professor Amai Mahesha, Dr. H. Ramesh, Dr. Basavarju Manu, Dr. Raviraj H. Mulangi, Dr. T. Nasar, Professor Shu-Qing Yang, Mr. Lim Sin Poh, Dr. Manoj Samuel, and Dr. Partha Sarathy, as presented in the report to Bangalore Water Supply and Sewerage Board (BWSSB) [4]. ■

References

[1] Sitharam T G, Rao R S and Kushal S, 2017, Innovative sea based fresh water reservoir to impound river flood waters: an initiative for India's water shortage, E-proceedings of the 37th IAHR World Congress August 13 – 18, 2017, Kuala Lumpur, Malaysia.
[2] Yang S Q, Liu J L, Lin P Z, et al. 2013, Coastal reservoir strategy and its applications. In Water Resources Planning, Development and Management, vol. 95-115.
[3] Integrated Hydrological Data Book. Released by Central Water Commission 2013.
[4] BWSSB Report (2017) Sitharam et al., "Coastal Reservoir at Mangaluru to Impound Netravati River Flood Waters – A feasibility Study in India", pp. 178.