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Alayande, A.W., and O.A. Bamgboye. 2019. “Tailwater Recycling for Hydro-power Generation, Niger River”. figshare. https://hdl.handle.net/2134/30437.

29th WEDC International Conference Abuja, Nigeria, 2003

TOWARDS THE MILLENNIUM DEVELOPMENT GOALS

Tailwater recycling for hydro-power generation, Niger River

A.W. Alayande and O.A. Bamgboye, Nigeria

THE WATER RESOURCES potential of the Niger River System is under natural and human induced stresses. Naturally induced stresses arise from climate change affects the potential rainfall and evapotranspiration within the basin while human induced stresses arises from harnessing the basin's water resources to meet agricultural, domestic, industrial and hydro-power developments of member nations within the Niger Basin Authority. Future water development in the basin is likely to generate political tensions as the nations within the basin compete for the control of an increasingly important and limited resource. While Mali and Niger are completely dependent on the Niger River for their water resource, Nigeria, which is the ultimate downstream riparian user of the Niger River flows is critically positioned and the continued operation of her renewable energy stations at Kainji and Jebba are at the mercy of upstream riparian users. In this paper an alternative source of water for the effective running of the Kainji and Jebba hydro-power stations were found in recycling the Jebba tailwater to the headwaters of the Malendo river systems. The result shows that a recycle of 60% of the flow at Lokoja back to Kainji reservoir will guarantee adequate supply of the daily water requirements for the generation of the full installed capacities of 760MW and 540MW of electricity at Kainj and Jebba.

Introduction

River Niger is the third longest river in Africa, 4100km long, after Nile and the Congo / Zaire rivers. It traverses two humid catchments separated by a wide expanse of semi-arid environment and four countries of Guinea, Mali, Niger and Nigeria in that order from the source at Fouta Djallon mountains to the Gulf of Guinea in Nigeria where it enters the Atlantic ocean through its delta. The entire basin covers nine countries of West Africa that together represents a Kaleidoscope of cultures and landscapes.

A combination of human population growth, desertification, unsustainable resource use and developments are threatening the ability of the Niger flows to supply the basins population with the much needed water resource. The World Wildlife Fund (WWF) reported in its publication "The River Niger River of Rivers" that the Niger river dried up completely for several weeks in 1985 at Malanville in Benin Republic. Despite that the Niger Republic is threatening to construct a multi-purpose dam on the Niger at Kandaji in addition to the Fomi dam in Guinea, Mekrou dam in Benin Republic and Tossaye dam in Mali. All these in addition to climate change impacts, desertification and water diversion activities for irrigation purposes by peasant farmers along the river course are pointers to an impending low inflow of the black flood waters into Nigeria. Excessive use or diversion of water for other purposes in the Sokoto-Rima basin can also render the contribution of the white flood into the Kainji lake very low. The Kainji and Jebba Plants are generating 22.31% of the total installed capacities of the NEPA generating facilities. All together the three hydro-stations including Shiroro plants are generating 32.1%.

Various individuals and organizations had in the past recommended alternative solutions to the low flow problems into the Kainji lake. NEPA on its part had initiated studies and design into four potential dam sites at Dasin Hausa, Makurdi, Lokoja and Onitsha but the main constraints to their implementation is the unacceptable environmental and socio-economic impacts of their very large reservoirs (Umolu J. C. 1990). Other efforts include Muriel Mirak-Weisbach (1997), and Bamgboye (1990)

Data/methodology

Hydrology of the Niger River system

The average rainfall at the headwaters of Niandan and Milo rivers at the source of the Niger at the Fouta Djallon mountains in Guinea and its exit to the sea in Nigeria is 2200mm. The river flow regime is characterized by two distinct flood periods occurring annually namely the White and Black floods. The black flood derives its flow from the tributaries of the Niger outside Nigeria (flow lag October to May) and arrives at Kainji reservoir (Nigeria) in November and lasts until March at Jebba after attaining a peak rate of about 2,000m^3/sec in February (Oyebande et al, 1980). The White flood is a consequent of flows from local tributaries especially the Sokoto-Rima and Malendo river systems. The White flood is heavily laden with silts and other suspended particles (flow lag June to September) and arrives Kainji in August in the pre-Kainji Dam River Niger having attained a peak rate of 4,000 to 6,000m^3/sec in September-October in Jebba. In the post Kainji Dam River Niger. The critical low flow period into the Kainji reservoir is March and July each year.

Kainji inflow and power generation potentials

An average daily discharge of 2280m^3/sec is required to sustain full generating capacity of 760MW or 3m/sec per unit Mega Watt of electricity. Figure 1.2 show the graph of the average daily inflow into Kainji for the years 1970 to

1989 an the potential power generation. The average daily inflow fell sharply from 1769m³/sec in 1970 to 759m³/sec in 1973 and thereafter stabilizes at a little above 1000m³/sec up till 1979 except in 1978 when the inflow was 729m³/sec. The inflow regime remained on the decline from its 1970 value to the end of 1989.

Between 1968 and 1976 the installed capacity was 320MW and the average daily inflow water requirement was 960m³/sec that was a little more than adequate for generating the installed capacity all year round even up till 1977. The commissioning of two additional 100MW turbines in 1978 brought the required average daily inflow to 1560m³/sec. Figure 1.1 shows that the inflow could not sustain the additional installed turbines. Further commissioning of additional two 120MW turbines or 760MW full installed capacity was coincidental to lower inflow of 729m³/sec when the required average daily inflow to run the installed turbines was 2280m³/sec. During the period 1988 to 1991 a total energy of 6,528,096MWH of energy was produced at Kainji,(JICA 1993), which translates to an effective average generation of 213MW out of installed capacity of 760MW.

Augmentation of the inflow into Kainji from Lokoja

About 177km³/yr of water is discharged into the Atlantic ocean via the Niger Delta. Out of this flow, the Niger receives 36km³/yr from Niger and 25km³/yr from Cameroun via the Benue River (FAO). The balance flow of 116km³/yr is produced by the tributaries of the Niger within the country. Therefore a redistribution of the excess flow of the Niger for beneficial use such as power generation at the Kainji and Jebba hydro-power stations will save the nation's renewable energy source of the problem of low water levels at the reservoirs and boost power generation.

Augmentation of the inflow to Kainji reservoir by 60% of Lokoja flow will have a double advantage of guarantee the required average daily inflow to generate the full installed capacities at Kainji and Jebba. This augmentation can be achieved through pumped storage system designed to recycle the 60% of the Niger flow at Lokoja either directly to the Kainji reservoir or to the headwaters of the nearest tributary of the Malendo river which can deliver the transferred water by gravity to the Kainji reservoir.. Figure 1.1 shows the viability of this concept in terms of meeting the objectives delivering sufficient water for power generation at the two hydro-power stations. The technical and economic feasibility of the concept is a subject of another paper to be delivered at a future date

Conclusion

The fact that Kainji dam was overdesigned can not be disputed in view of the prevailing inflow data available. The low inflow situation is expected to continue with increase in population within the Niger basin and the development of water resources to meet the needs of the population. However since the Lokoja dam cannot be

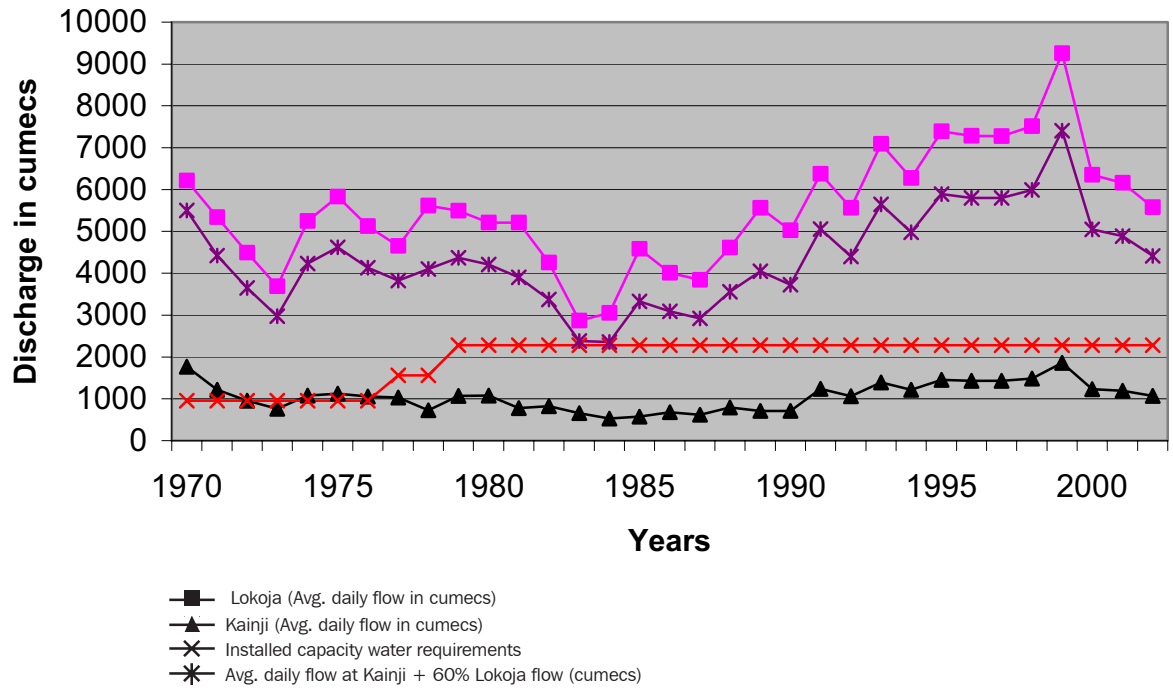


Figure 1. Average daily discharge of River Niger at inflow into Kainji reservoir and potential power generation

constructed due to varied implications, a recycle of the Kainji-Jebba tail-water flow at Lokoja back to Kainji reservoir provides a worthwhile alternative devoid of international politics of water between Nigeria and her neighbours.

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