Journal of Engineering and Applied Sciences 12 (18): 4778-4781, 2017
ISSN: 1816-949X

Study of Shallowing with Inflow-Outflow Method for the Restoration Model of the Bakaru Dam

Amrullah Mansida, Arsyuni Ali Mustari and Mahmuddin
Department of Civil Engineering, Faculty of Engineering,
University of Muhammadiyah Makassar, Sultan Alauddin Street 259th, Makassar, Indonesia

Abstract: Mamasa watershed as a water reservoir of Bakaru Dam has experienced a highly critical damage due to the dramatical increase in sediment rate annualy. Based on original analysis (New-Jec), the sediment rate in average was 133,000 m^3/years and the capasity of dam sediment was 6,919.900 m^3 (planning for 50 years). Based on analysis result from PT. PLN Persero Team and Hasanuddin Univeristy, however the sediment rate in average was 423.800 m^3/years while the capasity of dam sediment was 6,331.400 m^3. It remained 588.500 m^3 (±15 years) of dam capasity. The rapid declining brought the energy crisis of PLTA which produces +126 MW of electrical power in South Sulawesi Province. This research used descriptive explorative method which consists of three steps: preparation, field survey and testing sample, analysis of sediment rate using inflow-outflow method and silting of reservoir model restoration. As a result, it showed a incline in signifinal every years, note data ±589,197.00 m^3/years. Over the recent 11 yearss, the dam capacity was about 6,481.167.00 m^3 and remained approximately 438,732.00 m^3 reserved capacity (26 years). Because of this issue, taking real actions is extremely required to prevent or minimze the sediment rate that causes dam silting. There were two proposed methods non-structural method by restoring forests and agricultural lands and stuctural method by restoring sediment in the reservoir with the flushing channel model testing.

Key words: Mamasa watershed, inflow-outflow, prevent or minimze, restoring sediment, flushing channel model Indonesia, approximately

INTRODUCTION

Based on the previous research conducted by BPDAS Sadang (2011) using USLE method, the erosion rate is 1. 188.4 tons/ha/years. While the research conducted by Amrullah in the sub DAS Mamasa using MUSLE obtained the erosion rate to 854.08 tons/ha/years. It indicatesthat there is a correlation between the increase of the erotion rate andthe silting of Bakaru Dam. The study carried out by unhas and PT PLn (Persero), Bakaru sector in 2005 showed the erotionand sedimentation impact to the Bakaru Dam. This study proved that sedimentation went up significantly from 133.00 m^3/years in 1990-423.800 m^3/years in 2005. Because of that the dam volume comes down years by years. Beside that according to New-Jec 1990, the planed capacity for sedimentation is about 6,919.900 m^3 (50 years economic ages). But until June, 2005, after 15 years built, its dam capacity reached 6,331.400 m^3 and remained 588.500 m^3 of reserved capacity. This condition indicates that because of the great amount of sedimentation increase Bakaru Dam is in critical condition.

Along with the increasing sedimentation the reservoir capacity is getting smaller. The great amount of floating materials in the water flow can damage to the turbin componens on the plant. So, it will influence the provision of electrical energy generated by Bakaru hydropower plants 2×63 MW (126 MW). In addition, the delta formation or agradasi caused by sedimentation around the dam showed that there are no real actions taken by the authorities to handle this issue. Because of this issues this research is coducted to determine: how high the sediment rate of the damsilting is; how large a volume of the dam silting is; how to create a restoration method for solving the silting problems.

MATERIALS AND METHODS

The equipments used to check the field are GPS, plastic bags, meters, stationeies, whats flow, stop wacth, depth-measuring rope, path-measuring rope, small boat, sticks, floating tube, sample of sediment bottle, etc.

Corresponding Author: Amrullah Mansida, Department of Civil Engineering, Faculty of Engineering, University of Muhammadiyah Makassar, Sultan Alauddin street 259th, Makassar, Indonesia

The method used in this research was the advanced descriptive explorative method that was to determine the amount of sediment in the Bakaru Dam. Then, the sediments were analized in laboratory. Sampling of sediments in the Northern part of the reservoir approximately +7 km with a width of 70 m and a stream sediment sampling divided by five points in the transverse direction subzone Mamasa upstream.

The research was divided into three phases; the first step is preparation; the second steps are field survey, collection of data and sample testing; the third one is analizing the sediment rate using the inflow-outflow method and restoration model of dam silting.

RESULTS AND DISCUSSION

Generally, Mamasa watershed topography consists of hills, mountains with slopes more than 25%. Most of these locations are forests, scrubs, farms, settlements and rice fiels. In addition, the average elevation of the land is between 59-3000 m above sea level. The river where sample is taken has about 70 m of width and 160 m of depth in rainy season and 100 m of depth in dry season. Beside that, The maximum rainfall is approximately 310 mm with duration 13 days during a month between 1999-2004 and the annual avarage rain is about 122 mm Table 1 and 2.

Figure 1 and Table 3 show the amount of sedimentation in the dam using the inflow-outflow approach. The sediment rate is approximately 589,197.00 m^3/years while in the last 6 years period the capacity of dam sediment is about 6,481,167.00 m^3 and the capacity remains 438,732.00 m^3 (26 years). It proved that the dam capacity of economic ages (6,919.900 m^3) will not meet with the previous prediction. Therefore, we need to take concrete actions to restrore Bakaru watershed to decrease or press the rate-sediment potency to the dam and dam shallowing.

The high sedimentation rate every years is caused by some factors Rain erosion factor (R). The rainfall in Mamasa water shed and Bakarudam is relatively high. The rain duration in 1 month is about 13 days and the precipitation is about 122 mm based on StaBakaru, StaMamasa and StaSamarorong during 16 years period (1999-2014). Maximum rainfall is 310 mm (February 18, 2003 and 2009 Stasamarorong). Erodibility factor (K) is the resistance of the soil particles that are peeled and the transportation of soil particles due to the kinetic energy of the rain with a value 0.2156. The trigger is an increasing number of the open land used as agricultural land without proper conservation. The topography condition of most of the Mamasa water shed is steep with slope above >25%. Plant management factor, the use of land without doing conservation continuously or replanting can easily cause peeling of soil. Factors chipped soil structure because no menstabilitasi or strengthen the surface resistance to be able to put a halt to the kinetic energy of the rain, factors cliff erosion, the vegetation roles are preventing and reducing erosion cliffs through some processes, binding the soil particles by vegetation, reducing the soil humidify through evapontranspirasi process and the potential of land slides; increasing the infiltration rate, so the surface runoff causing cliff erosion decreases, the plant roots in the river can precipitate sediment.

Table 1: The analitical results of the sediment-rate potency of the first step entering the dam (m^3/year) in the rainy seasion (May 2016) with inflow-outflow method

Observation points	Debit (Q) (m^3/dt)	Cs (seci disk) (mg/L)	Cs (Lab.) (mg/L)	Unit weight (ton/m^3)	Q_s (ton/day)	Q_s (m^3/8 months)
I (left river)	11.044	1,075.45	6,196.00	0.87	3,469.32	733,448.40
II (middle 1)	9.388	1,019.73	6,734.00	0.92	3,144.51	702,986.41
III (middle 2)	9.388	1,230.66	16,034.40	0.97	7,001.81	1,650,396.89
IV (right river)	4.970	722.63	13,495.00	0.85	6,104.67	630,460.12
Mean	-	-	-	-	4,930.08	929,322.95

Table 2: The analitical results of the sediment-rate potency of the second step in the dry season (September, 2016) with inflow-outflow method

Observation points	Debit (Q) (m^3/dt)	Cs (Lab.) (mg/L)	Unit weight (ton/m^3)	Q_s (ton/day)	Q_s (m^3/4 months)
I (left river)	0.458	9,908.33	0.842	367.54	39,223.55
II (middle 1)	3.679	4,451.67	0.803	1,361.94	145,941.41
III (middle 2)	4.682	10,071.67	1.035	4,085.76	514,952.71
IV (middle 3)	3.569	7,103.33	1.073	2,994.59	403,972.05
V (rigth river)	3.498	3,716.67	0.828	1,214.26	141,270.33
Mean		7,050.33	0.916	2,004.82	249,072.00

Tabel 3: The analitical results of the sediment-rate potency entering the dam (m^3/year)

Observation points	Debit (Q) (m^3/dt)	Cs (seci disk) (mg/L)	Unit weight (ton/m^3)	Q_s (ton/day)	Q_s (ton/year)	Q_s (m^3/ year)
I (left river)	5.751	8,052.17	0.842	1,918.43	444,493.60	386,335.98
II (middle 1)	6.533	5,592.83	0.803	2,255.22	368,616.93	424,463.91
III (middle 2)	7.035	13,053.03	1.035	5,543.78	1,097,743.30	1,082,674.80
IV (middle 3)	5.100	7,103.33	1.073	2,994.59	387,955.76	403,972.06
V (rigth river)	4.269	8,605.33	0.828	3,659.46	444,710.64	385,865.23
Mean	6.097	8,832.47	0.916	3,467.45	631,179.41	589,197.48

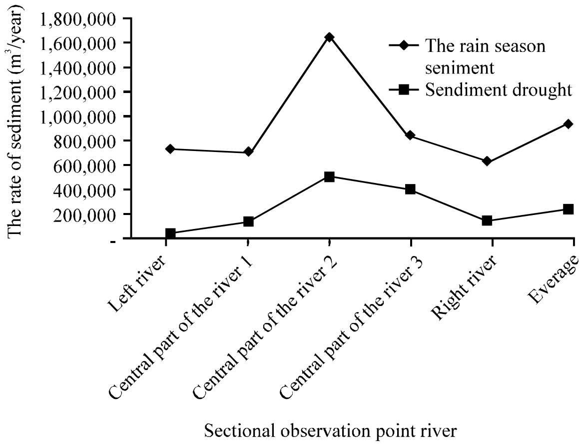

Fig. 1: The graph of relationship between sampling locations and sediment rate entering the dam (m^3/year)

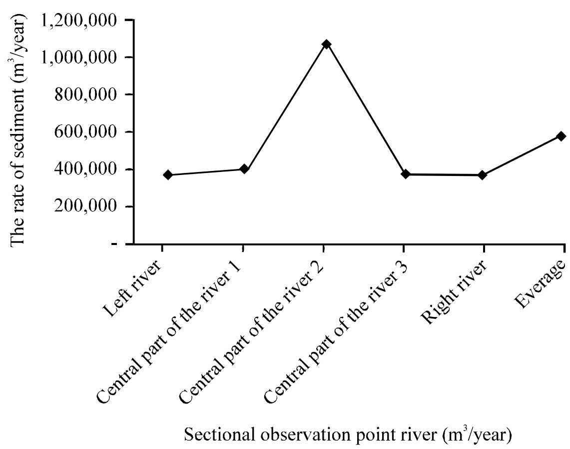

Fig. 2: The graph of relationship between sampling locations for floating sediment and sediment volume on the dam (m^3/year)

In Fig. 2 and Table 3 shows that a concentration of sediment in the middle part of the river is high enough cross-section of a five-point sampling sediment drift. It shows that the drainage of the river in the central part generally has a relatively high speed. because in the middle it does not have barriers with roughness factor so that the speed can be accelerated and cause the centered sediment concentrations.

Riparian forest restoration: Watershed management requires an integrated concept. The existence of water resources in this earth should be controlled with the bio-geo-physical aspects. Management considers four aspects, namely; aspects of atmospheric water, surface water, ground water aspects (geohydrology), conservation and management aspect. For today's conditions the paradigm of watershed management with ecology and hydrology approaches or called ecohydrology. Ecohydrology is defined as the study of the interactions between hydrological processes and biological dynamics in various spatial and temporal conditions (Suprayogi, 2013). Environmental conservation is required to prevent the watershed damage (Rahim, 2012).

Restoration of agricultural land: Environmentally benign drainage concept of (eco-drainage) is a key concept in the field of international drainage. Eco-drainages that are easy to implement, among others; conservation pool, artificial recharge, the river side polder method and ground water protection area method (Maryono, 2008, 2007).

Restoration of Bakaru Muddy Bam: The selection of restoration model was based on the sediment condition of Bakaru Dam or almost all reservoirs experience sedimentation problems. Concrete steps are needed to resolve this issue. The results of the analysis became the basic framework for modeling flushing conduit (Mansida, 2011) by disentangling then forward to pipeline to the building of door dewatering and dam spill way. This model is expected to be used for short and long term (required test experimental models).

CONCLUSION

Based on the above description, it could be concluded as: the estimeted sediment rate in the Bakaru Dam using the inflow-outflow approach was about 589,197.00 m^3/year). Over the recent 11 years, the dam capacity was about 6,481,167.00 m^3 and remained approximately 438,732.00 m^3 reserved capacity (26 years) where the planned capacity was about 6,919,900.00 m^3 (50 years). All of it caused by the damage of Mamasa watershed as the water supply for Bakaru hydro plant. There were two proposed methods; non-structural method by restoring forests and agricultural lands and stuctural method by restoring sediment in the reservoir with the flushing channel model testing.

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