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THE EFFECT OF SAND TRAP ON SEDIMENTATION DISTRIBUTION OF CIRATA DAM TO MAINTAIN THE RESERVOIR AGE OF USE

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ABSTRACT: Cirata Reservoir is one of the largest reservoirs in Indonesia. This study aims to perform a numerical analysis of the sedimentation distribution pattern based on geometry, sediment, and discharge of the Cirata Reservoir. Numerical analysis was performed using SSIIM-2 (Sediment Simulation in Intakes with Multiblock Option) software. From the simulation results of 5 years from 2013 to 2017, an average addition of sediment volume was 8.966 million m^3/year. When inspected from each river inflow of Cirata Reservoir, the distribution of the contribution of sedimentation in the Cikundul River, Cibalagung River, Cisokan River and Citarum River are 12.19%, 20.34%, 28.39% and 39.07% respectively. From the analysis of the sedimentation distribution to the position of the dead storage in the reservoir, it was found that of the total sediment that entered Cirata Reservoir, only 4.10% reached the elevation of the dead storage in the downstream area of the reservoir. These results were used to determine the appropriate sedimentation treatment pattern, with the treatment recommended being a sand trap. The sand trap type recommended for sediment treatment would be located downstream of each river at inlet to the reservoir. These sand traps are expected to withhold up to 70% of sediment that would settle in the reservoir.

Keywords: Computational fluid dynamics, Dead storage, Numerical modelling, Reservoir lifetime, Sediment distribution, SSIIM

1. INTRODUCTION

Cirata reservoir is one of three cascade reservoirs in Citarum River, namely Saguling Reservoir, Cirata Reservoir, then finally Jatiluhur Reservoir (Fig. 1). Citarum river is located in the West Java Province of Indonesia, this river flow from Wayang Mountain of West Java to the Java Sea, especially in Karawang Region. The effective capacity of Cirata Reservoir, in the year of 2017 is 1,432 million m^3 [1], Cirata Reservoir is expected to supply clean water and for irrigation through Jatiluhur Reservoir, furthermore as a hydroelectric power plant that generate up to 1,008 MW. Operational problems in reservoir management are known to occur, one of which is sedimentation and a decrease in the volume of water capacity. A study conducted by PT PJB BPWC (Pembangkitan Jawa Bali - Cirata Reservoir Management Agency), now called PT PLN Nusantara Power UP Cirata, in 2012 concluded that the reduction in storage capacity was equivalent to a sediment deposit of 55,471 tonnes/day in Cirata Reservoir [1,2]. This significant sediment deposition rate might be caused by the high rate of erosion in the water catchment area, from the river upstream of the reservoir. Moreover, fish farming activities by the community using floating cages can also contribute to the additional sediment in the reservoir [3,4].

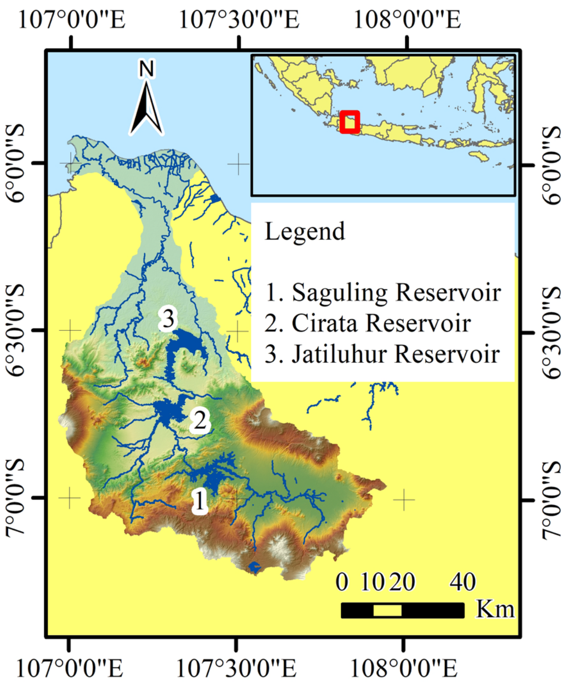

Fig. 1 Location of Cirata Reservoir's within Citarum's cascade dams, located between Saguling Reservoir and Jatiluhur

The high rate of sedimentation in the reservoir can reduce the normal volume of the reservoir thereby reducing the effectiveness of the service [3 – 6]. The effectiveness of reservoir operation can be determined by calculating the volume of transported sediment and measuring it using relatively expensive bathymetry [7,8]. This shows that it is necessary to do numerical modelling that facilitates the analysis of the effectiveness of treatment sedimentation problems in reservoirs [9 – 11].

2. RESEARCH SIGNIFICANCE

The purpose of this research is to study sedimentation patterns in the Cirata Reservoir. This includes analyzing the distribution, buildup, and erosion of sediment and how the reservoir's operation affects water flow. This study aim to determine the sediment amount from each river flowing into the reservoir and where it accumulates. This helps measure how much sediment fills the reservoir's dead storage volume and assess the sedimentation rate and the reservoir's lifespan. Since Cirata Reservoir is one of the important contributors to electricity supply in Indonesia, it is necessary to pay attention to its water storage and sedimentation so that the reservoir will continue to benefit the Indonesian people. The goal is to develop sediment management strategies to ensure the Cirata Reservoir operates effectively for its intended lifespan.

3. METHOD

The data needed in the preparation of this study are rainfall and climatological data; digital elevation data on the Cirata Reservoir Catchment; reservoir topography and bathymetry data; soil grain diameter data (grain size); reservoir inflow discharge data; sediment inflow data in the reservoir.

3.1. Topography and Bathymetry

The topographical and bathymetric situation data from the reservoir must be processed in such a way as to become digital elevation data to facilitate geometric modelling in the numerical model of the reservoir [12-16]. Digital data processing is carried out using the help of vector processing software and mapping on a computer [12,15, 17]. The data used for this is from the 2017 bathymetry survey from PT PJB BPWC.

3.2. Hydrology and Sedimentation

In modelling waterflow and reservoir sedimentation, operational discharge data is needed so that optimal results are obtained [10,18,19]. The reservoir inflow discharge data needs to be modelled as input for the sedimentation simulation at a later stage.

In this study, the inflow data was obtained from the rainfall runoff discharge modelling using HEC HMS software [20]. The parameters needed to model the runoff discharge that will be used as the inflow of the Cirata Reservoir include the basin model, meteorological model, control specification and time series data. The discharge parameter used to model the reservoir is the dominant discharge. The use of dominant discharge is carried out with the aim that the discharge that occurs can carry sediment and produce a distribution of sediment motion that represents field conditions.

This study uses a tool in the form of SSIIM (Sediment Simulation in Intakes with Multiblock Option) software developed at NTNU Norway by Nils Reidar Olsen. Modelling is done by inputting flow rate data (runoff discharge) which is solved by the Navier-Stokes equation, and for sediment transport simulation is solved by the convection-diffusion equation [21]. Sedimentation distribution analysis was carried out to find out the amount of sedimentation in each river flowing into the Cirata Reservoir [1,11,22]. In addition, it is also necessary to study the distribution of sediment distribution in the reservoir to find out where the position of sedimentation is due to inflow into the Cirata Reservoir. This is done to find out how much sedimentation fills the dead storage volume of the reservoir [23 – 25]. This information is required so that analysis of sedimentation rate and useful life of the reservoir can be carried out.

The results of the numerical modelling of sediment in the reservoir using SSIIM-2 are changes in the bed changes due to flow that occurs during rinsing. So that it can be known how much sediment volume is eroded or rinsed by the reservoir operation process. Using SSIIM-2 software with the geometry of the entire reservoir, the distribution of sediment according to the depth and condition of the bottom contour of the reservoir could be obtained. In modelling the distribution of sedimentation, it is necessary to prepare the sediment and discharge parameters to be used [21].

3.3. Calibration

The calibration plan that will be carried out in this study is to compare changes in sediment volume from the simulation results that have been carried out with measurements of the existing measured sediment volume. So that later it will be compared and calibrated using the absolute error method Eq.(1):

$$Absolute\ error = \left|\frac{x_{Numeric} - x_{Physical}}{x_{Physical}} x100\%\right| \quad (1)$$

The model results that are considered acceptable or verified are models with an error value of <5%. If the desired results have not been achieved, then some model parameters need to be calibrated.

3.4. Reservoir Age of Use

With the annual sediment rate, each reservoir is planned for a certain useful life [26 – 29]. One of the objectives of this study is to obtain a pattern of treatment sedimentation problems in order to maintain the useful life of the reservoir [2,29,30-31]. The calculation steps to determine the sedimentation rate and the useful life of the reservoir are, firstly to determine the rate of sedimentation in the inflow reservoir (tons/year), secondly determining trap efficiency [32], third is calculating the sediment retained in the reservoir by multiplying the sedimentation rate by the trap efficiency, and lastly calculating sediment density over time and its effect on volume [1,33]. The equation used are by Lara and Pemberton (1963) Eq. (2), Eq. (4), Eq. (5) and by Miller (1953) Eq. (3):

$$V_T = \frac{ET}{W_T . T} \quad (2)$$

$$W_T = W_0 + 0.4343K\left(\frac{T}{T-1} . \ln T - 1\right) \quad (3)$$

$$W_0 = W_c . P_c + W_m . P_m + W_s . P_s \quad (4)$$

$$K = K_c . P_c + K_m . P_m + K_s . P_s \quad (5)$$

Wherein V_T is Sediment volume settled after T years (m^3), E_T = Sediment in Reservoir (m^3), W_T = The average density of settled sediments after T years (kg/m^3), W_0 = Initial average density (kg/m^3), K = Consolidation Coefficient. Pc (clay), Pm (silt), and Ps (sand) are symbols for percentage of clay, silt, sand in the sediment settled in the reservoir and Wc, Pm, and Ps are for density of clay, silt, sand in the sediment settled in the reservoir.

After understanding the impact of sedimentation on the reservoir storage, efforts must be made to address this issue [34]. One of them is through structural treatment in the form of a sand trap. A sand trap is a structure built in the river before the water enters the reservoir [34 – 37]. Its purpose is to settle a portion of the sediment before entering the reservoir, thereby reducing the sediment concentration in the reservoir [34,36]. The dynamics of a sand trap for sedimentation treatment is fairly simple, in Fig. 2 as flows through the river, bringing sediment along with it, but as it enter sediment trap the flow velocity decreases because of change in depth and width of the channel making the sediment grains fall into the pool. This remaining small percentage of suspended sediment carried into the reservoir, and once again because the change of channel width as it left sand trap into reservoir, making the flow velocity increased and the sediment grains hauled further into the storage and fall beyond the reservoirs upstream.

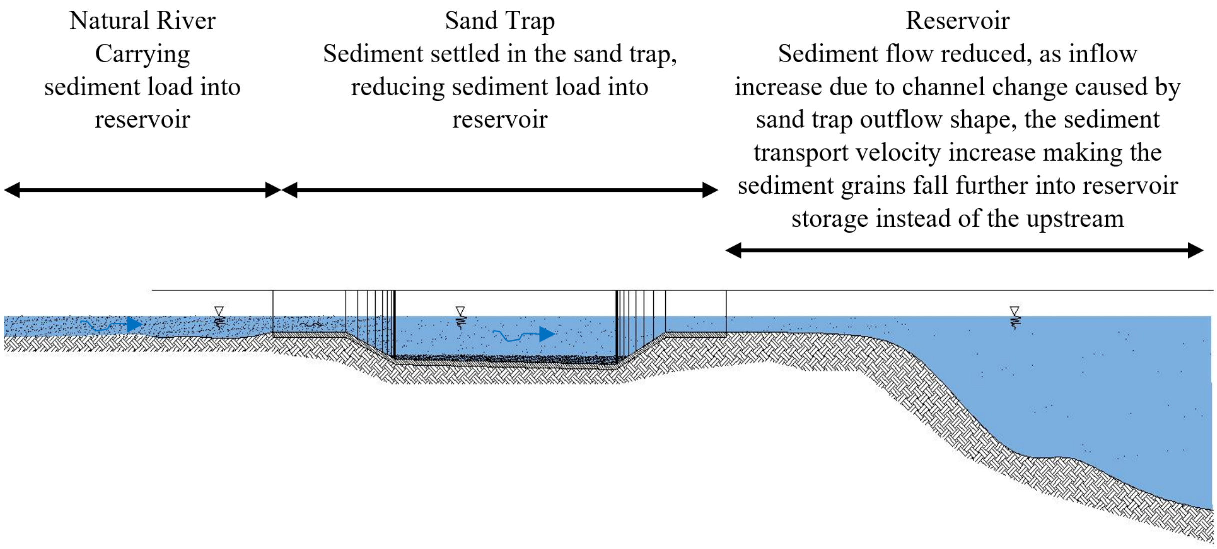

Fig. 2 The use of sand trap to decreases sediment load into reservoir

4. RESULT AND DISCUSSION

Sedimentation modelling in this study was carried out using the SSIIM-2 software. In this software, modelling is carried out in 2 (two) stages, namely waterflow computation (inflow discharge) and sediment computation. The results of this waterflow computation will then be input for the sediment computation. The initial stages in modelling using SSIIM-2 include grid generation; preparation of reservoir geometric data and reservoir inflow; preparation of control files; flow discharge input; interpretation of waterflow computation results [21,38-40].

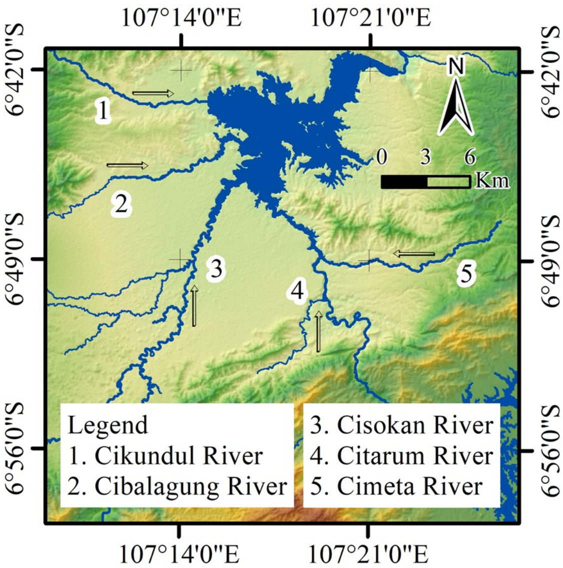

Fig. 3 River Inflow of Cirata Reservoir

Cirata reservoir receives water inflow from 5 major rivers in Citarum's Catchment area, which were Citarum River (with addition of Saguling Reservoir's outflow), Cimeta River, Cisokan River, Cibalagung River, and Cikundul River. Albeit Cimeta River empties into Citarum River before entering Cirata Reservoir, the river holds enough effect on the sedimentation rate of Cirata Reservoir as shown in Fig. 3.

4.1. Sediment Model Simulation and Calibration

Computational sediment calibration in this study was carried out by comparing the measured sedimentation volume with the simulation results. Measurement data were obtained from the results of annual measurements at the hydrology stations of each Cirata Reservoir inflow river. The measurement data that will be used is data for 2017 in November because it is the beginning of the wet season and is expected to represent the discharge that occurs in accordance with the calculated discharge that has been carried out by the previous flow computation.

Calibration was carried out on 3 rivers, namely the Cikundul River, Cibalagung River and Cisokan River because only measurement data were available for these rivers. From the results of calculating the volume of riverbed changes in the model, it can be determined that changes in riverbed volume before and after computation are the volume of sediment entering the Cirata Reservoir. So that it can be compared and calibrated the sedimentation volume data in the model against the measurement data. Calibration was performed using the absolute error method. With result shown in Table 1.

From the results in Table 1 of the model sedimentation volume calibration against the measurement data, the absolute error values for the Cikandung River were 4.43%, the Cibalagung River were 3.38% and the Cisokan River were 1.84%. These results indicate that the error in the sedimentation model has a value below 5% so that the sedimentation model can be used.

Table 1. Sediment volumetric model calibration result

Information	Cikundul (m^3/day)	Cibalagung (m^3/ day)	Cisokan (m^3/ day)
Observation	60,325.15	127,374.07	128,584.58
Model	62,995.95	131,674.95	130,948.20
Error	- 2,670.80	- 4,300.88	- 2,363.62
Abs. Error	4.43%	3.38%	1.84%

4.2. Cirata Reservoir's Sediment Modelling

Sedimentation analysis was performed using SSIIM-2 software with the geometry of the entire reservoir. This is done to get the distribution of sediment according to the depth and condition of the bottom contour of the reservoir. In modelling the distribution of sedimentation, it is necessary to prepare the sediment and discharge parameters to be used.

The discharge parameter used to model the reservoir is the dominant discharge. The use of dominant discharge is carried out with the aim that the discharge that occurs can carry sediment and produce a distribution of sediment motion that represents field conditions. The dominant discharge data used is Q50 for 2013-2017.

The sediment parameter used is D50 in the middle of the reservoir with a grain diameter of 0.013 mm. So, for the fall velocity parameter, a value of 0.002 cm/s is obtained. The duration of the modelling is time step 86400 with an inner iteration of 30 trials.

4.3. Cirata Reservoir Sedimentation Distribution

4.3.1. Sedimentation Distribution in Upstream River of Cirata Reservoir

Modelling for the analysis of sedimentation in each inflow river of the Cirata Reservoir was carried out partially by modelling the geometry of each inflow river of the Cirata Reservoir as far as 3 km. So that later it will be known the effect of sedimentation on each inflow and which river has the dominant sedimentation contribution from the 4 inflow rivers of the Cirata Reservoir. Modelling is carried out with parameters according to the calibration results in the previous section with discharge data being the dominant discharge in each river. From the modelling results, it can be known the amount of sedimentation by calculating changes in the riverbed before and after modelling. The tabulation of sedimentation volume calculation results is shown in Table 2.

Table 2. Sediment volume percentage from each upstream inflows of Cirata Reservoir

River	Sediment Percentage (%)					Avg (%)
	2013	2014	2015	2016	2017	
Cikundul	12.26	12.15	12.04	12.25	12.27	12.19
Cibalagung	20.35	18.37	19.44	22.10	21.45	20.34
Cisokan	28.87	28.98	28.34	27.90	27.89	28.39
Citarum	38.52	40.51	40.18	37.75	38.40	39.07
Total	100	100	100	100	100	100

From the results in the Table 2 analysis above, it can be seen that the Citarum River, which is an outflow from the Saguling Reservoir, is the river with the highest sediment inflow. This is because the discharge from the Citarum River is the largest so that with the same geometric data it produces the largest sedimentation disposition compared to the other inflows or rivers.

4.3.2. Sedimentation Distribution in Accordance to Dead Storage

Following the results of sedimentation simulations carried out for 5 years (2013-2017) using dominant discharges, it is shown in Fig. 4, Fig. 5, Fig. 6, Fig. 7, and Fig. 8 bellow that the dominant distribution of sedimentation occurs around the estuary of the Cirata Reservoir inflow. This shows that not 100% of the sediment that enters from the inflow river reservoir fills at the dead storage elevation position, which is at +180 elevation.

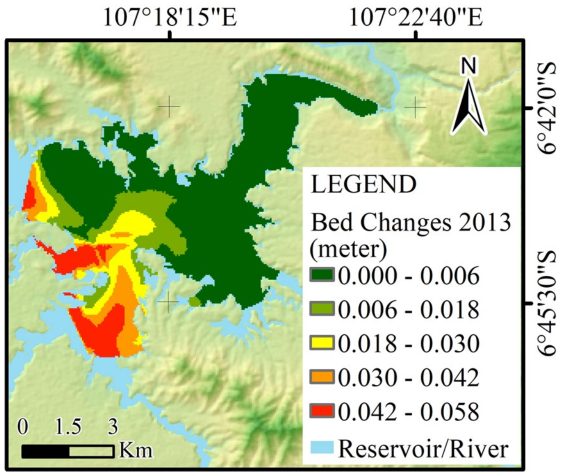

Fig. 4 Sedimentation distribution in accordance to dead storage elevation in 2013

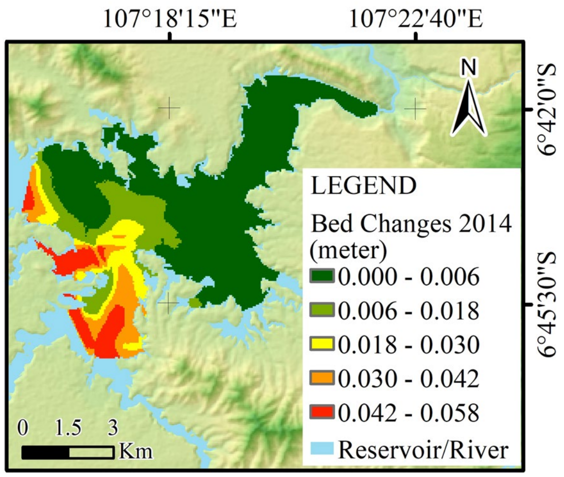

Fig. 5 Sedimentation distribution in accordance to dead storage elevation in 2014

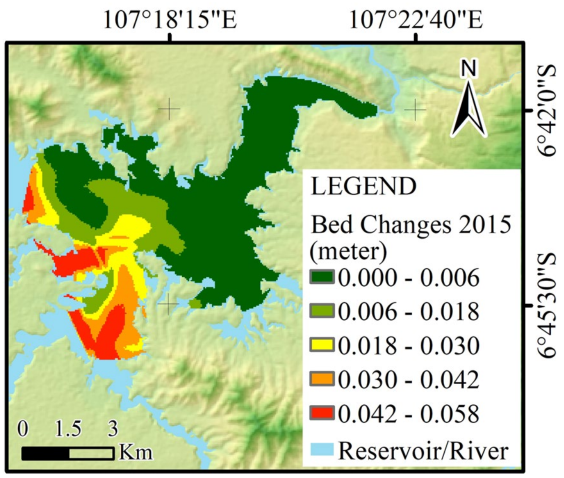

Fig. 6 Sedimentation distribution in accordance to dead storage elevation in 2015

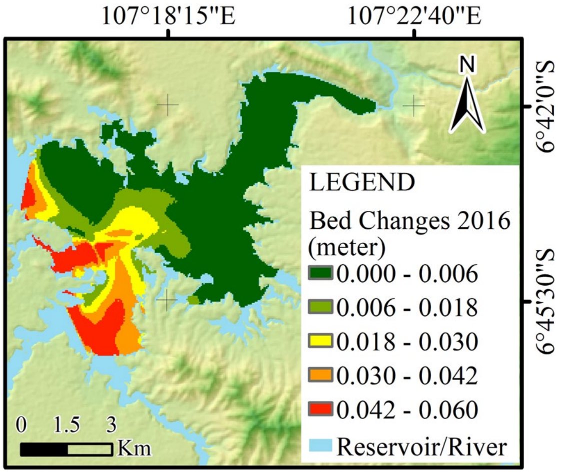

Fig. 7 Sedimentation distribution in accordance to dead storage elevation in 2016

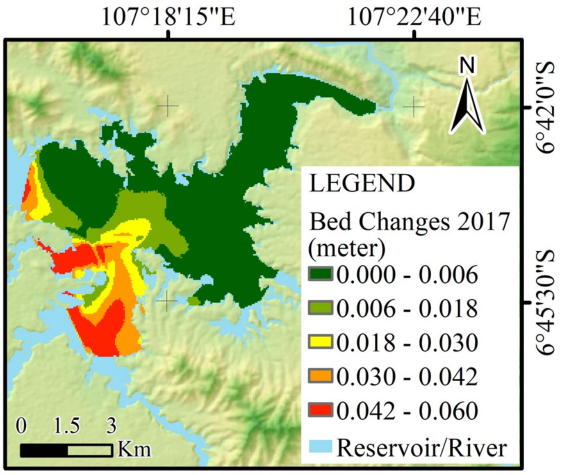

Fig. 8 Sedimentation distribution in accordance to dead storage elevation in 2017

Fig. 4 to Fig. 8 above shows the bed changes from sedimentation settlement throughout the year, and it indicate that the most bed changes occur around reservoir's inlet from 4 inlet rivers (as Cimeta River merges with Citarum River before entering Cirata Reservoir) and it depleting as it get further into the reservoir. From the results of the analysis of the percentage volume of sediment that entered dead storage during modelling from 2013 to 2017, it was found that an average of 4.10% of sediment entered dead storage elevation from the total sediment entering Cirata Reservoir. This meant that most of the sediment entering Cirata Reservoir settled in effective storage.

4.4. Reservoir Sedimentation Rate Analysis

Calculation of the sedimentation rate of the Cirata Reservoir is carried out to determine the amount of sediment entering each year by considering the change in average density with the age of the sediment. The data used for analysis are sediment density and consolidation factor; reservoir storage volume to reservoir elevation; percentage of reservoir sediment composition and reservoir sediment inflow [41].

Table 3 Density and consolidation factor based on reservoir operations.

Ty-pe	Reservoir Operation	Starting Coefficient (kg/m³)			K Factor		
		S	M	C	S	M	C
1	Sediment always submerged or nearly submerged	1550	1120	416	0	91	256
2	Normally moderate to considerable reservoir drawdown	1550	1140	561	0	29	135
3	Reservoir normally empty	1550	1150	641	0	0	0
4	Riverbed sediments	1550	1170	961	0	0	0

Table 4 Calculation of sediment deposits for T years

Year	Sr	TE	W_T	$V_{T\text{-}TC}$	$V_{T\text{-}ES}$	$V_{T\text{-}DS}$
	10^6 ton/yr		ton / m^3	10^6 m^3		
2020	10.15	0.96	1.13	8.57	8.22	0.35
2024	10.15	0.96	1.17	49.95	47.90	2.05
2028	10.15	0.96	1.19	123.18	118.13	5.05
2032	10.15	0.95	1.20	227.66	218.33	9.33
2036	10.15	0.95	1.21	362.79	347.91	14.87
2040	10.15	0.95	1.22	527.85	506.21	21.64
2044	10.15	0.94	1.23	721.86	692.26	29.60
2048	10.15	0.93	1.23	943.22	904.55	38.67
2052	10.15	0.91	1.24	1,188.93	1,140.18	48.75
2056	10.15	0.87	1.24	1,451.95	1,392.42	59.53

Sr = Sediment rate annual average, TE = trap efficiency, W_T = average density of settled sediments after T years, V_T = sediment volume settled after T year, $V_{T\text{-}TC}$ = total cumulative of = sediment volume settled, $V_{T\text{-}ES}$ =sediment volume settled in effective storage, $V_{T\text{-}DS}$ = sediment volume settled in dead storage

From Table 3 above, it is known that Cirata Reservoir is a reservoir that is always flooded every year, so the density values used are Wc=416 kg/ m^3, Wm=1120 kg/ m^3 and Ws=1550 kg/ m^3. Soekarno et al. (2020), their study determined the presentation of each Pc (clay), Pm (silt) and Ps (sand) of Cirata Reservoir is at 27%, 26% and 47%. Cirata Reservoir storage volume from sounding data by PT PJB BPWC in 2017 found that the effective storage capacity of the reservoir at an elevation of +280 is

1432 million m^3. The annual sediment inflow used is constant with the results of sediment modelling calculations for 5 years with an average annual sediment inflow of 8.966 million m^3/year.

Capacity: inflow (C: I). The data is needed to determine trap efficiency to determine how much sediment is retained at the bottom of the reservoir. With these data, it can be analyzed how much sediment volume settles in the reservoir and 4.10% of the inflow of sediment that fills the dead reservoir.

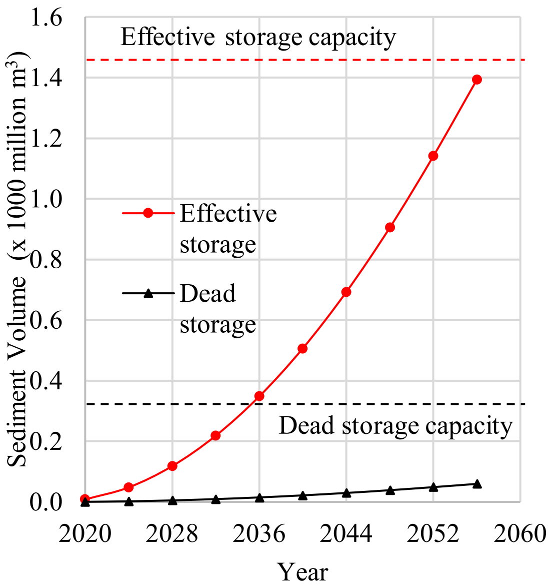

Fig. 9 Comparison between existing sediment inflow volume in effective storage and dead storage

Table 4 shows the results of the analysis of the sedimentation rate in the Cirata Reservoir, after 37 years of operation starting from 2020, the volume of sediment at the dead storage elevation is filled with 59.35 million m^3 or 20.67% of the dead storage capacity. However, as demonstrated in Figure 9, it should be noted that there is sedimentation of 1392.42 million m^3 which fills the effective reservoir of the reservoir. This shows that the effective storage capacity of the reservoir is 97.24% filled with sediment, where the normal storage capacity of the reservoir is 1432 million m^3. This undoubtedly will affect the operation of the dam as a hydroelectric power plant.

4.5. Cirata Reservoir Sedimentation Treatment Recommendations

From the results of this study, it is known that the dominant distribution of sedimentation originates from the Citarum River and enters the normal elevation of the Cirata Reservoir. Technically, there has been a solution for the problem of sedimentation inflow from rivers, namely the placement of check dams in several rivers which are inflows from the Cirata Reservoir.

The efforts to deal with sedimentation in the Cirata Reservoir in the future can be carried out using alternative treatment with a structural approach, namely sand trap, which could be placed in the river before entering the reservoir.

4.5.1. Sedimentation Treatment Alternative with Structural Approach

There are various methods to deal with sedimentation, especially in reservoirs, including by implementing sediment control structures, repairing green belts around inundations, and improving the watershed upstream of the reservoir. The main problem of sedimentation in the Cirata Reservoir is the large supply of sediment from the rivers that become the inflow of the Cirata Reservoir. One method that can be applied to the Cirata Reservoir besides the check dam is to apply a sand trap at the mouth of the Cirata Reservoir inflow (Fig. **10**).

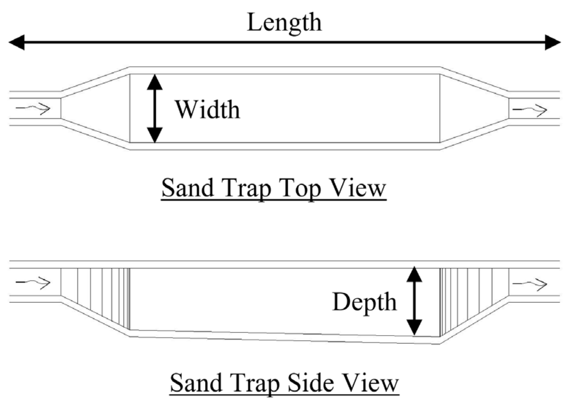

Fig. 10 Typical model of sand trap

The plan for the placement and dimensions of the sand trap for each inflow river of the Cirata Reservoir is carried out by maximizing the dimensions and placing it as close as possible to the reservoir without relocating the existing land use. From the laying plan, the following dimensions are obtained (Table 5).

Table 5 Calculation of sand trap storage volume and dimensions

Location	H	W	L	V
	(m)	(m)	(m)	(m^3)
Cikundul	5	100	450	225,000
Cibalagung	5	100	500	250,000
Cisokan	5	180	725	652,500
Citarum	5	150	750	562,500
Cimeta	5	135	550	371,250

H = depth, W = width, L = length, V = volume

The treatment pattern that will be applied by applying the sand trap is by extracting the settled sediment. With the volume of available storage and the volume of sedimentation in each inflow river of the Cirata Reservoir, it is possible to estimate the pattern of sedimentation treatment and control required within 1 year of operation. In this study, monthly sedimentation simulations have been carried out with dominant discharge in the Cirata Reservoir inflow river. From these results it was found that the monthly average sediment inflow over the last 5 years was 151,624 m^3 in the Cikundul River, 229,822 m^3 in the Cibalagung River, 312,476 m^3 in the Cisokan River, 417,799 m^3 in the Citarum River and 50% of the Cimeta River sediment from S. Citarum sediments. Assuming that the dominant sedimentation occurs during the rainy season (6 months), then the sediment treatment pattern in the sand trap can be determined as follows in Table 6.

Table 6 Sediment treatment patterns in sand traps

Source Inflow	Average monthly sed. volume	Sedimentation every 6 months	Sediment extraction pattern	
Cikundul	151,624	909,745.29	5	times / year
Cibalagung	229,822	1,378,934.28	6	times / year
Cisokan	312,476	1,874,858.67	3	times / year
Citarum	417,799	2,506,796.91	5	times / year
Cimeta	208,899	1,253,398.46	4	times / year

4.5.2. Sedimentation Treatment Effectiveness Analysist in Accordance to Reservoir's Age of Use

With the application of sand traps according to their respective capacities, assuming the extraction is carried out periodically and the sediment capture capability of the sand trap is considered 70%, the effectiveness of sediment capture in each river justified in Table 7 below.

Table 7 Sediment deposition effectiveness on sedimentation rate

River	Average annual sedimentation (million m^3)	Sediment effectiveness	Annual sedimentation rate (million m^3)
Cikundul	1,068	70%	320
Cibala-gung	1,814	70%	544
Cisokan	2,581	70%	774
Citarum	3,501	70%	1,050
Annual Sedimentation Rate			2,689

From the results of these calculations, it can be concluded that the construction of a sand trap with an efficiency of 70% is able to reduce the sedimentation rate to 2,689 million m^3/year. So, with an estimate of the implementation of the sand trap in 2025, the sedimentation rate and useful life of the Cirata Reservoir can be calculated with the following results in Fig. 11.

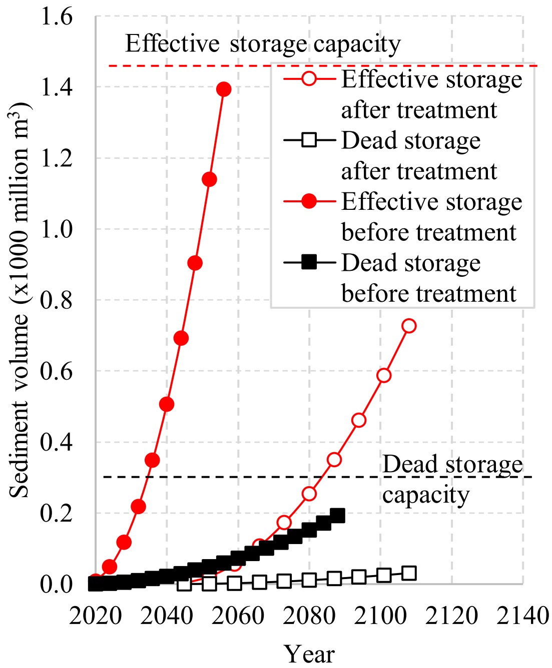

Fig. 11 Comparison between sediment inflow volume in effective storage and dead storage after treatment

From these results shown in Fig. 11 it can be seen that in 2087 or 100 years since the Cirata Reservoir began operating, after treatment implementation, sediment entering the reservoir was 751.58 million m^3, of which 30.81 million m^3 (10.70% of dead storage capacity) filled the dead storage and 720.76 million m^3 (50.33% of the effective storage capacity) fills the effective storage. This is considerably favourable to the alternative, without any treatment, as even 100 years after Cirata Reservoir's operation the dead storage would not be fully filled and there's still space left in the effective storage. Compared this to reservoir storage changes before the treatment considered, the sediment would fill almost most of Cirata Reservoir's storage before began filling up the dead storage. This shows that the Cirata Reservoir is still useful and has a longer life than the planned useful life of the reservoir after the implementation of the treatment, in this case sand traps in every inflow river.

5. CONCLUSION & RECOMMENDATIONS

From the results of the analysis and discussion carried out in the study of Distribution of Sedimentation in Cirata Dam and Treatment in

Efforts to Maintain Reservoir's Age of Use, the following conclusions can be drawn:

1. Numerical modelling for sedimentation analysis was carried out with the SSIIM-2 program and calibrated in each Cirata Reservoir inflow river. The sedimentation model data for the Cirata Reservoir inflow river was calibrated against observational data on the Cikundul, Cibalagung and Cisokan Rivers. The volumetric calibration results with the absolute error method show that all models have an error value below 5% so that the numerical model can be used.
2. Sediment simulations in the inflowing rivers of the Cirata Reservoir are carried out with wet and dry month discharge data according to the flow simulation. From the simulation results, the average sedimentation carried by all rivers from 2013 to 2017 accumulated to 8.966 million m^3/year.
3. The results of analysis of the distribution of sediment sources were carried out in each Cirata Reservoir inflow river by numerical modelling using the SSIIM-2 program. From these results it was found that the dominant sediment volume that entered the Cirata Reservoir came from the Citarum River with an average percentage of 39.07%.
4. The results of the analysis of the distribution of sedimentation distribution were carried out by calculating the volume change resulting from numerical modelling only in the dead storage elevation area in 2013-2017. From the calculation of the sediment volume at the dead storage elevation, it was found that the sediment entering the dead storage elevation was 4.10% of the total volume of sediment entering the Cirata Reservoir.
5. From the results of the analysis of the sedimentation rate, it was found that after 37 years of operation, the volume of sediment at the elevation of the dead storage was filled with 58.77 million m^3 or 20.40% of the capacity of the dead storage and in the effective storage was 1374.54 million m^3 or 95.99% of the total effective storage.
6. With the application of sediment treatment in the form of a sand trap, it can be calculated the effectiveness of reducing the sediment rate on the useful life of the reservoir. Assuming that the sand trap can capture 70% of the incoming sediment and the sediment extraction from the sand trap is carried out periodically, the useful life of the Cirata Reservoir can reach the planned useful life of 100 years from 1987 or until 2087. In accordance with the results of the effectiveness analysis, in 2087 effective storage is filled with 720.76 million m^3 (50.33% of the effective storage capacity) and the dead storage is filled with 30.81 million m^3 (10.70% of the dead storage capacity.)

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