SEDIMENTATION RATE IN GAJAH MUNGKUR RESERVOIR CENTRAL JAVA, INDONESIA

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ABSTRACT

*Gajah Mungkur reservoir is a multipurpose reservoir with broadness of 8.800 ha. Its functions for irrigation, hydroelectric power, source of drinking water, tourism, aquaculture and Presently the sustainability of reservoir function is distressed by emerging of wrinmnation. The sedimentation may be reduced water volume, create siltation, decrease cariying capacity, create rust and corrosion on the turbine engine. The aims of the research is to observe the sedimentation rate at Gajah Mungkur reservoir as a base line study on the reservoir management model. The research has been counducted at Gajah Mungkur Reservoir, Camel of Jawa during the period of February to Desember 2011. In order to estimate bathymetry of this reservoir the acoustic survey methods has been applied whitest the sit traps is applied to estimate the sedimentation rate. The results of this research showed that maximum depth was 16 m, average depth was 6.07 m, average water volume was 408.512.270 m^3. Compared to the situation when the reservoir was built in 1981/1982 the average depth was 9 m, average water volume was 630,000,000 m^3- It is mean that after 28 years **there** is a reduction of water volume about 201,088,000 m^3 and reduction of water depth 2.93 m. The sedimentation rate was higher during the rainy season i.e. 2,76 m^3I hal day, The average sedimentation rate in one year was 6 cm/year, 593.71 m^3/ha/year, 822.53 tons/ha/ year.*

Keywords : *Sedimentation, Water Volume, Siltation, Reservoir.*

INTRODUCTION

Reservoir posses not only a strategic *value* but also multipurpose use **for t**he economic activities (**Saban,** 2008). Gajah Mungkur reservoir **is** situated at the Solo River meted during the period of 1981to 1982 by drowning 51 villages and 67.157 people relocated out of Java throught transmigration scheme. This reservoir is located in Wonogiri District Central Java, with water surface area 8.800 **ha,** 140 m above sea level. Gajah Mungkur reservoir is multipurpose initially, it functions was for **lircation,** hydroelectric power, source of drinking water, however, it also aircraft for tourism, aquaculture and fisher (Utomo et al., 2010). The problem encountered were sedimentation and eutrophication. Sedimentation derived from erosion of rainwater runoff and erosion from the upper stream of the river. Eutrofication derived from anthrophogenic factors *such* as agricultural, domestic and industrial wastes, as well aquaculture such as floating cage culture (Sukimin, 2008).

Currently, the sustainability of reservoir function is distressed by emerging of sedimentation.Sedimentation can reduce water volume, siltation, reduce carrying capacity, rust and corrosion on the engine turbine. When the reservoir was built in 1982, sediment thickness up to 3 mm / year. In 2000, sediment thickness reached 8.8 mm/year (Departemen Pekerjaan Umum Dirjen Pengairan,1992;Direktorat Pengetotaan Bengawan Solo, 2003). Twenty four years later from the time when this reservoir began to operates in 1984, the volume of sediment *entered the reservoir up* to 168,719 million meters cubic, which is the average of sedimentation rate per year was 7.03 million meters cubic, while the effective volume for irrigation remain 341 million meters cubic (Direktorat Pengelolaan Bengawan Solo, 2008; Jasa Tirta, 2008).

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The volume of water in the reservoir has also been affected to the carrying capacity of fish culture. The large volume of water will be more carrying capacity of fish culture. Small volume of water that otherwise would be less carrying capacity of fish culture (Utomo *et a!.,* 2011). In order to formulate the policy on the sustainable water resources development at Gajah Mungkur Reservoir for present and the future, the main problems and challenges should be taken into account. The key factor causing the above mentioned problems was the high volume of sediment entered into the reservoir. The aims of the research is to observe the sedimentation rate at Gajah Mungkur Reservoir as a base line study for reservoir management model.

MATERIAL AND METHODS

The study was conducted in 20/1, *November* 2011 and December 2011. The research methodology was direct observation to the field and laboratory analysis of materials samples have been collected during that periods.

1. Acoustic Survey

In order to estimate the bathymetry of the reservoir, the acoustic survey using Simrad EY 60 was conducted in February 2011 (Table 1). The acoustic is placed on the right hand side of the 8 GT wooden boat. The placement of the equipment was to avoid the noise from the muffler of the boat. Since the reservoir is a closed area, therefore, the design of the transect to measure the depth was by zig-zag method. This method is to prevail the bathymetric from reservoir side to the centre in order to figure out of it contours (Figure 1) (FAO, 1980)

Reservoir bathymetry data were compared to data when the reservoir was built, subsequently we get the reduction of water volume as a result of sedimentation that entered into the reservoir (Jasa Tirta,2008; Fakultas Perikanan dan Ilmu Kelautan Universitas Riau,; Dirjen Sumberdaya Air dan Pusat Studi Ilmu Teknik Universitas Gajah Mada,2003).

Table 1. Acoustic Equipment

No	Equipment	Used
/	Acoustic: Portable Scientific Echosounder SIMRAD EY-60, transducer 120 KHz	The main equipment acoustic
2	One unit portable powe generator, 1000 Watt	Electricity power
3	Wooden boat 8 GT.	Transporting and installing acoustic equipment
4	Laptop with memory >2 GB, Hardisk >80 GB	Data acquisition
5	Personal Computer (PC). Memory >2 GB, Hardisk >80 GB	Post processing data
6	Software ER60	Processing data
7	Software SONAR-4	Processing data

2. Estimation of sedimentation rate by using sediment traps using the following formula

The study has been conducted at nine sites representing the type of water reservoir: (1) Middle Site near the island; (2) Inlet of Wiroko Site; (3)Site near cage culture of PT. aqualam; 4) Cage Culture area Site;Inlet of Keduang Site; (6) Outlet site (7) Inlet of Bengawan Solo Site;(8) Inlet of Alang site; (9) Inlet of Wurantoro Site (Figure 2).

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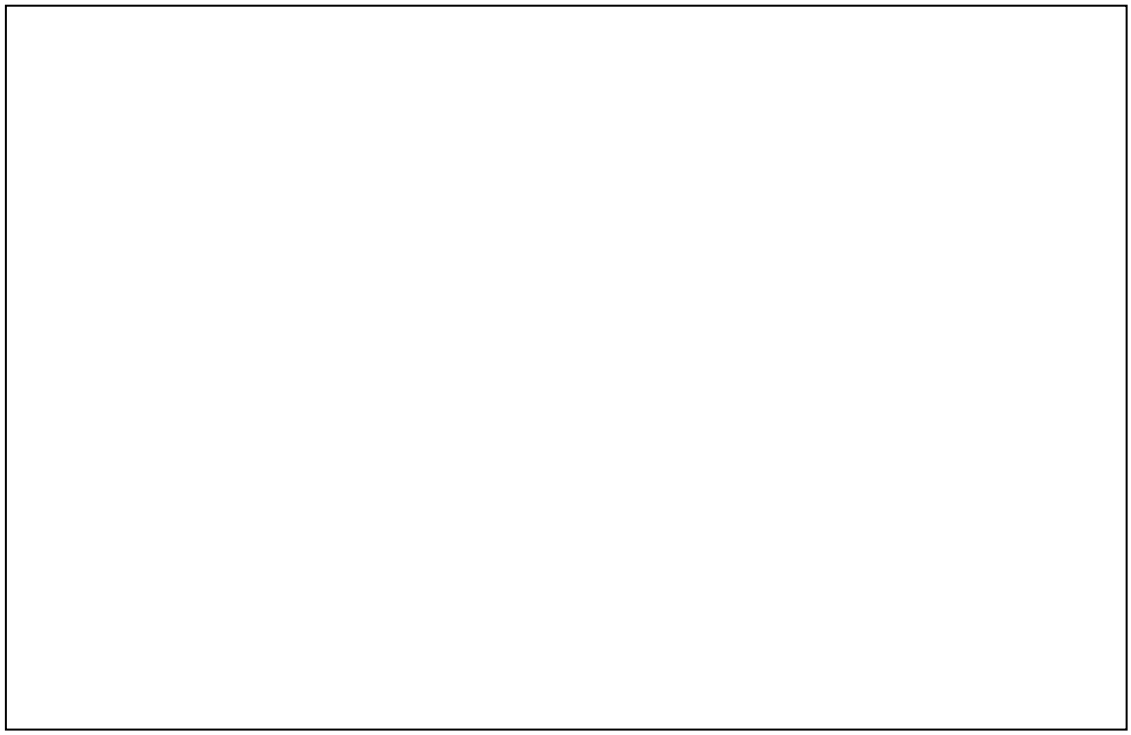

Figure 1. Acoustic transects design in Gajah Mungkur Reservoir.

Sediment traps was placed in the bottom waters for a few days. Sediment deposition in sediment traps were analyzed in the laboratory. The sedimentation rate was calculated Estimation of sedimentation rate by using sediment traps using the following formula (APHA 1986; Morgan, 1979; Sulistyo, 2000):

$$Ls = \frac{-\mathrm{W/A}}{\mathrm{W/A}}$$

$$Ls = \frac{}{T}$$

Remarks:

- Ls = Sedientation rate (ml/cm^2/day, or gram/cm^2/day)
- W = Sediment deposition (gram, or ml)
- A = Square of sediment traps
- A = ri.r^2 (cm^2)
  r = radius circle of **sediment** traps (5.25 cm)
- T = Interval time (day)

RESULT AND DISCUSION

Based on the acoustic survey (Table 2 and Figure 3); the result showed that maximum depth of Gajah Mungkur Reservoir was 16 m wit the average depth of 6.07 m and the average water volume was 428,912,270 m3. Compared to the reservoir when *was built in* 1981 to 1982: *the average* depth was 9 m and average water volume was 630,000,000. In other words, there is a reduction of water volume of 201,088,000m^3 and reduction of water depth 2.93 in after 28 years later.

The reduction in the depth and water volume was due to the sedimentation entered into the reservoir. The catchments area around reservoir is 70% made up of yard, moor, and *dry* land. The forests may bear *up* erosion only 13.2%, the banks of the river into the reservoir often to grow crops (Wijarnako, 2010).

Based on the experimental of **sediment** traps (Table 3); the result **showed that** the average of siltation: (0.012 Cm/day + 0.010 cm/day + 0.028 Cm/day)/3= 0,016 Cm/day, or 6 Cm/year. The average sedimentation rate in units of volume (ha) was (1.15 m3/ha/day + 0.96 m3/ha/day + 2.76 m3/ha/day)/3 = 1.63 m3/ha/day, or = 593.71 m3/ha/year. The average of sedimentation in units of weight (ton) was (1.48 ton/ha/day+1.69 ton/ha/day+3.59 ton/ha/day)/3 = 2.25 ton /ha/day, or 822.53 ton/ha/year.

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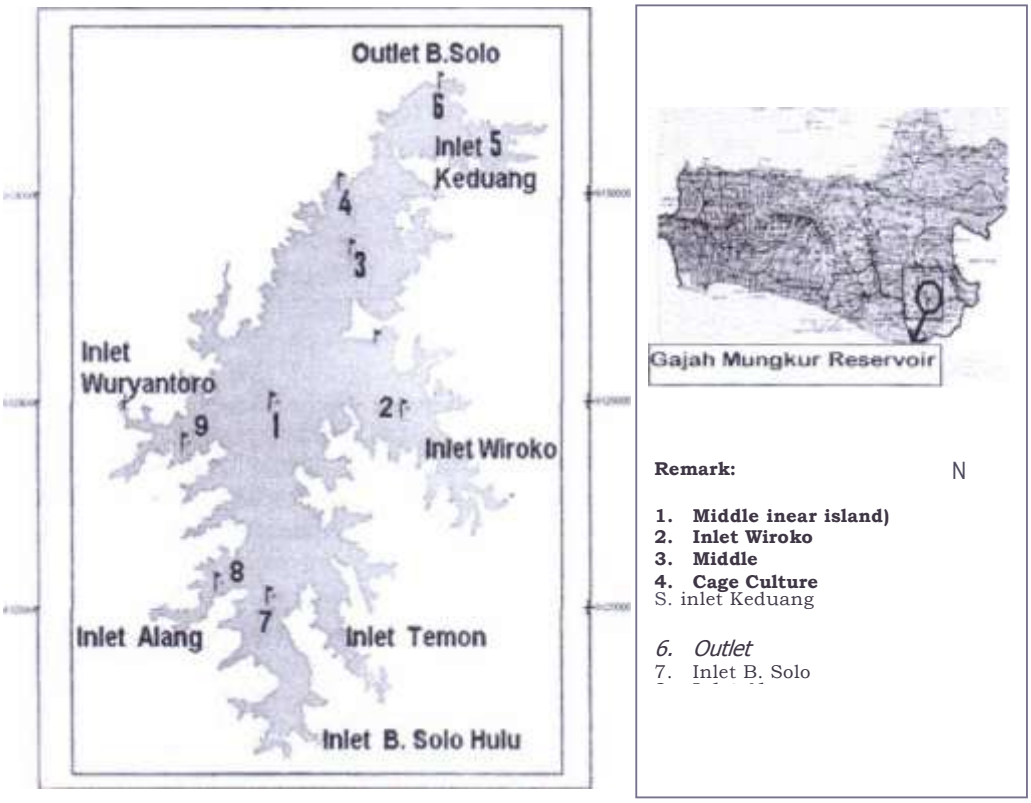

Figure 2. Location Site Map of Sediment Sampling

Tabel 2. Depht, vast and water volume of Gajah Mungkur Reservoir

Depth (m)	Vast (m^2)	Volume (m^3)
>0 -2	16.710.000	33.420.000
>2- 4	12.840.000	38.520.000
>4- 6	9.549.000	47.745.000
>6- 8	5.508,000	38.556.000
>8- 10	8.701.000	78.309.000
>10- 12	7.319.000	80.509.000
>12- 14	6.148.000	79.924.000
>14- 16	3.886.000	58.290.000
Average depth 6,07 m	70.661.000	Average Water Volume 428.912.270

The Sedimentation rate was larger during the rainy season (0.96 m^3/ha/day) than during the dry season (2.76m^3/ha/day) due to the land affected by erosion entered into the reservoir, particularly land around the reservoir that used by the farm communities.

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

- The sedimentation rate in Gajah Mungkur Reservoir was 593.71 m^3/ha/year and it is considered to be very high.
- The reduction in the depth and water volume was caused by sedimentation process entered into the reservoir.

2. Recommendations

In order to recover the reservoir as was built, using land on the banks of the reservoir for agriculture is not allowed and it is highly recommended to lift the silt from reservoir.

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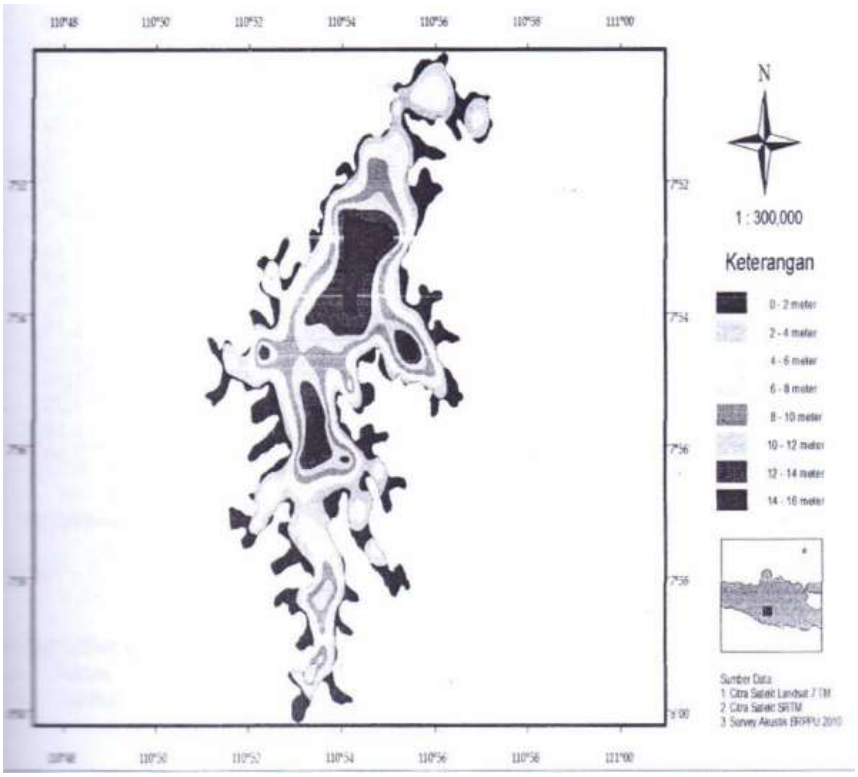

Figure 3. Bathymetry Map of Gajah Mungkur Reservoir

Tabel 3. Sedimentation Rate at Gajah Mungkur Reservoir

	Location and Month	Sedimentation Rate		
		Cm/day	m3/ha/day	Ton/ha/day
A	November 2009			
1.	Inlet Wiroko	0.06	0.58	0.59
2.	Center 1	0.012	1.15	1.51
3.	KJA PT.Aquafarm	0.06	0.58	1.88
4.	KJA Masyarakat	0.012	1.15	0.74
5.	Outlet	0.023	2.31	2.68
Average		**0.012**	**1.154**	**1.48**
B	July 2010			
1	Center 1	0.012	1.18	2.27
2	KJA PT.Aquafarm	0.013	1.33	2.28
3	KJA Masyarakat	0.006	0.62	1.07
4	Outlet	0.007	0.72	1.14
Average		**0.010**	**0.96**	**1.69**
C	December 2011			
1.	Inlet Bengawan Solo	0.036	3.60	4.68
2.	Inlet Alang	0.030	2.98	3.87
3.	Inlet Wurantoro 1	0.026	2.62	3.41
4.	Inlet Wurantoro 2	0.040	3.99	5.19
5.	Inlet wiroko 1	0.045	4.48	5.83
6	Center 1	0.015	1.51	1.96
7	Inlet Keduang	0.013	1.33	1.73
8	Outlet	0.016	1.59	2.08
Average		**0.028**	**2.76**	**3.59**

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