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SEDIMENT DELIVERY FROM RIGHT BANK VALLEYS TO MOSUL RESERVOIR, IRAQ

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Abstract- Mosul dam reservoir is the biggest reservoir on the River Tigris with 11.11 billion m3 storage capacity located at the northern part of Iraq. The dam is used for irrigation, hydropower generationand flood control.
Siltation of the reservoir and sediment delivery from the valleys to the reservoir was not measured since the operation of the dam in 1988. Sediment accumulation in its reservoir can effect the dam operation (pumping station, hydropower plantsand bottom outlets) and it will definitely shorten the life span of the dam.
In this study, the Soil and Water Assessment Tool (SWAT) under Geographical Information System (GIS) was applied to simulate the yearly surface runoff and sediment load for the main three valleys on the right bank of Mosul Dam Reservoir for the period 1988-2008. The resultant values of the average annual sediment load are $42.7*10^3$, ton. This implies that significant sediment load enters the reservoir from these valleys. Sediment accumulation can effect the dam operation (pumping station, hydropower plantsand bottom outlets) and it will definitely shorten the life span of the dam. To minimize sediment effect, check dams are to be constructed specially on the first valley.
Keywords- Mosul Dam, Runoff, Sediment load, SWAT model, GIS.

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Introduction

Deposition of sediment in reservoirs can cause serious problems. They reduce the storage capacity of the reservoir and they can cause serious problems concerning the operation and stability of the dam (Yang, 1996[1]).

Sediment delivered to the reservoir comes from two main sources. The first source is the main river entering the reservoir and the second source is the side valleys on both sides of the reservoir.

Due to the importance of the problem Due to the importance of the problem several empirical methods were developed and later modeling techniques was adopted (US Department of Interior, Bureau of Reclamation, 2006[2]).

Several types of models are used to predict sediment load. Among these Srinivasan et al.,1998[3]; Fernandez, et al., 2003[4]; Kim H., 2006[5]; Yüksel et al., 2008[6]; Baigorria and Romero,2007[7]; Engda, 2009[8];Gitas et al., 2009[9]; Nangia et al., 2010[10]; Jain et al.,2010[11]. In 2008, Kim, J. et al [12] developed the SWAT ArcView GIS Patch II for steep slope watersheds. Dos Santos, et al. (2010[13]) applied these model and got good results on Apucaraninha River watershed in southern of Brazil. Douglas-Mankin, K, et. al. (2010[14]), reviewed and introduced a number of selected papers which present and applied the Soil and Water Assessment Tool (SWAT).

The objective of this study is to estimate the runoff volume and sediment loads entering Mosul Dam Reservoir from the main valleys on the right bank side. The accumulated yearly runoff and sediment loads were estimated for the period from 1988-2008. This period represent the first 20 years of the life operation of the dam.

Study Area

The studied area is located north of Iraq on the right bank of Mosul Dam reservoir. The dam is about 60 Km north of Mosul City (Figure 1). There are three main valleys that pour the runoff and the sediment load in the reservoir directly. High percent of studied area is a planted with seasonal crops (wheat and barley), vegetables and pastures, while the soil classification is mostly of silty loam, silty clay loamand clay, (Mohammad, 2006[15]). Table (1) shows the topographic properties of the three studied valleys 1, 2and 3 (Figure 1).

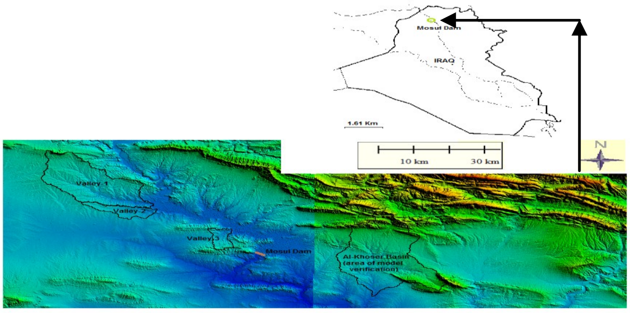

Fig. 1- Location of Mosul dam with the main valleys in the right bank

Table 1- The topographic properties of the main valleys in the right bank of Mosul Dam

Valley No.	Area (km²)	Slope %	Length (km)	Shape factor	Average level (m.a.s.l)
1	450.76	3.59	38.80	3.5	446.62
2	78.52	2.17	21.82	6.09	388.38
3	50.06	5.25	10.86	2.36	404.89

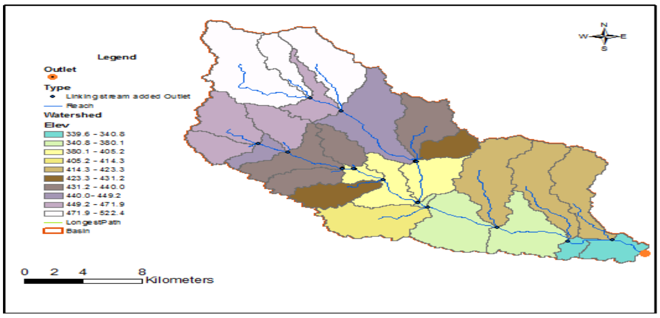

Fig. 2a- Watershed boundary, sub-basins elevationand flow net of valley-1

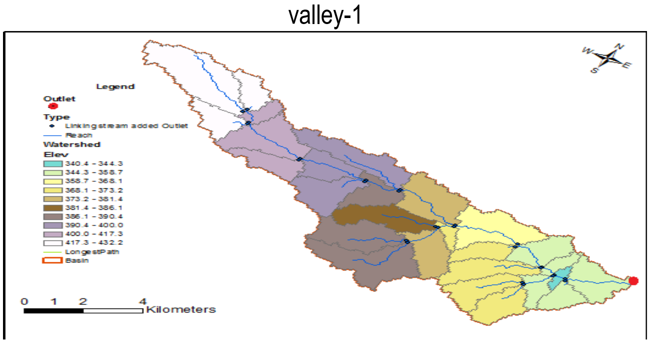

Fig. 2b- Watershed boundary, sub-basins elevationand flow net of valley-2

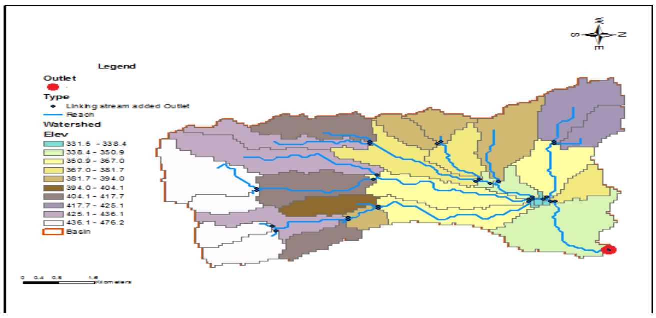

Fig. 2c- Watershed boundary, sub-basins elevationand flow net of valley-3

For valley one shown in Figure 2(a), the maximum elevation is 770.2 m.a.s.land the minimum elevation near the outlets is 313.5 m.a.s.l. About 96% of the valley area is covered with a winter wheat crop, while the remaining 4% is a pasture land. The soil classification distribution is 63% of silty loam, 27% is silty clay loamand the remaining 10% is clay soil. For valley two shown in Figure 2(b), the maximum elevation is 449.3 m.a.s.land the minimum elevation is 306.5 m.a.s.l. The crop cover area is 67.3% with winter wheat and vegetablesand 32.7% is pasture lands. The soil classification is 64% is silty loam, 25.6% clayand the remaining 10.4% is silty clay loam. For valley three shown in Figure 2(c), the maximum elevation is 543.5 m.a.s.l.and the minimum elevation near the outlet is 313.9 m.a.s.l. About 46.2% of the total area in valley three is covered with wheat crop, 45.2% agricultural landsand remaining 8.6% is pasture lands. The soil classification is 68.4% silty loam, 20.9% silty clay loamand 10.7% is clay soil.

Application of the Model

Soil and Water Assessment Tool (SWAT) is a physically based model was developed to simulate and predict the runoff, sediment loadand agricultural chemical yields for large and complex watersheds having different soil type, land use (Arnold et al., 1998, 2000; Neitsch et al. 2001) as quoted by Asharge (2009[16]). The model is a continuous simulation tool which can be applied for long period of time.

In SWAT model, the surface runoff is estimated by two methods (Winchell, et. al. 2007 [17]): curve number procedureand Green-Ampt infiltration method. In curve number method the values of the curve number (CN_2) which is the tabulated curve number considered for average conditions. These values corrected for dry condition (CN_1) and for moisture conditions (CN_3). Calculation of infiltration (Chow, 1988[18]), effective hydraulic conductivity is given by (Nearing et al. 1996[19])

These values corrected In SWAT model the estimation of erosion and sediment load yields based on Modified Universal Soil Loss Equation (MUSLE) (Williams 1995 as quoted by Chaplot. 2005 [20]).

In order to verify and evaluate the model's results, similar watershed was used. This watershed referred to as al-Khoser Seasonal River near the study area (Figure 1). The selected watershed is similar to the studied area in geology, surface soil and climate (Jassim and Goff, 2006[21]). The studied area covers about 695 km2. The main part of the area is a silty clay loam, silty clay, silty loam, which covers 72, 6and 4% respectively. The silty clay loam area is useful for agricultural use; it is planted with wheat and barley in winter seasons. The remainder is bare soil throughout the year due to its either low or high infiltration rate except some pastures. The remaining 18.0% is composed of dolomite, limestone, marl and marly limestone, which is very tough and highly jointed and fracturedand can not be used for agricultural practices (Al-Naqib, 1980[22]and Mohammad 2005[23]). Three single storms were measured in this area (Mohammad 2005[23]), including the rainfall depth, runoff and sediment hydrographs. These storms were simulated in SWAT Model to evaluate and calibrate the model to be verification for the studied area. The observed and simulated runoff depth and sediment concentration for the three considered storm are shown in Table (2). The model results evaluated based on determination coefficient (R2)and Nash-Sutcliffe coefficient, model efficiency (E) as quoted by Engda (2009)[8]. The results showed a good agreement between the observed and simulated values for both runoff volume and sediment load and for the equivalent runoff volume. The determination coefficient between observed and simulated values was 0.94 and the Nash-Sutcliffe, model efficiency value (E) was 0.81. Accordingly, it is acceptable to apply the model and the difference between observed and simulated runoff volumes is insignificant. Also for the sediment load, the determination coefficient and Nash-Sutcliffe model Efficiency values were 0.92 and 0.77 for the considered storms, this means that the correlation is good and there is no significant difference between observed and simulated values. The results of sediment concentration are also evaluated and gave same range of evaluation considered criterion.

Table 2- Observed and simulated runoff volume and sediment load for the considered storm of model verification

Storm No	Date	Rain (mm)	Observed Runoff Vol. (MCM)	Simulated Runoff Vol. (MCM)	Observed Average Sediment Load (*10^3ton)	Simulated Average Sediment Load (*10^3ton)
I	19-02-2003	19	0.912	0.806	1.68	1.325
II	15-01-2004	9	0.13	0.139	0.078	0.158
III	22-01-2004	17	1.39	1.772	2.933	3.83

Results and Discussion

The daily rainfall data, maximum and minimum temperature, sunshine, humidityand wind speed of Mosul Dam and Mosul stations for the period 1988 to 2008 were considered in this study. The data were used to estimate the annual runoff volume and sediment load that delivered from the main valleys of right bank on Mosul Dam Reservoir. The Soil and Water Assessment Tool SWAT was considered for yearly simulation for both runoff and sediment of the three considered valleys.

The results of total annual runoff volume indicates that the average value are 20.61$0^6$, 3.11$0^6$and 0.8*10^6 m^3 for valleys one, twoand three respectively. The contribution of these valleys for the reservoir inflow rate is limited. The annual runoff volume for the considered period is shown in Figure 3 for the three valleys. This figures shows that the maximum yearly runoff volume for the considered valleys is in 1993 which are equal to 62.0*10^6, 9.7*10^6 and 2.8 *10^6 m^3 for the three valleys respectively, that is due the maximum annual rainfall depth in that years which is about 656 mm. The minimum runoff volume are 0.28*10^6, 0.021*$10^6$and 0.02*10^6 m^3 for the three valleys respectively for the year 2008 which had a minimum average annual rainfall depth of the three valleys (78 mm).

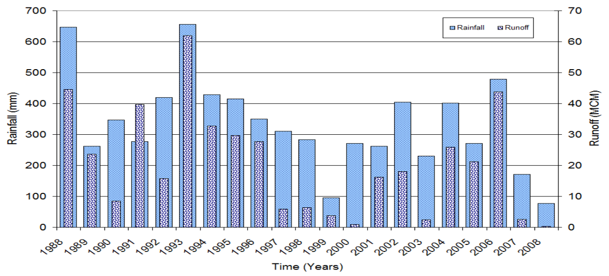

Fig. 3a- Yearly rainfall depth and runoff volume of valley-1 for the considered period

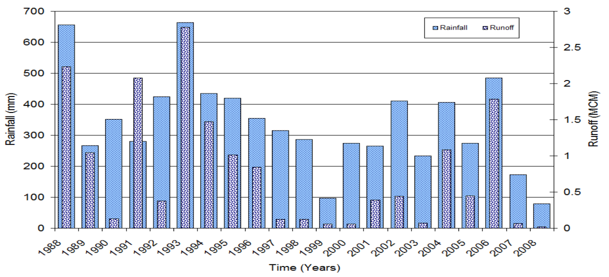

Fig. 3b- Yearly rainfall depth and runoff volume of valley-2 for the considered period

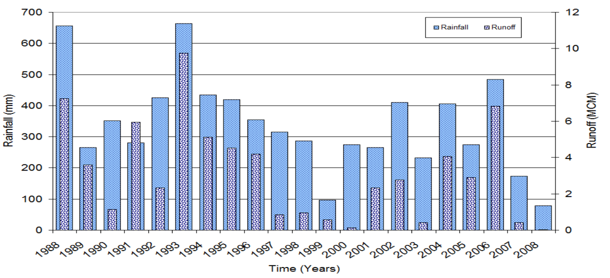

Fig. 3c- Yearly rainfall depth and runoff volume of valley-3 for the considered period

The results of sediment load indicate that the average annual load carried by the runoff flow is 35.6*10^6, 4.9*$10^6$and 2.2*10^6 ton for the three valleys respectively (Figure 4a, band c). The average value of sediment concentrations are 1.73, 1.60and 2.73 kg/m^3 respectively (Figure 4a, band c). From these figures, we can see that the sediment concentration is highly fluctuating with time. This is due to the effect of rainfall intensity variation and other factors effecting sediment load concentration. The maximum sediment concentrations are 3.2, 2.7and 4.5 kg/m^3 for the selected valleys respectively for the year 1988. The maximum rainfall intensity in that year was 63mm/day. The number of rainy days in that year was little while the intensity was high (35, 30 and 20 mm/day) and this was reflected on sediment concentration. Another year (1993) also has relatively high sediment concentration. In this year the rainfall depth and runoff volume are the maximum, while the sediment load is not the maximum value. This is due to the fact that the rainy days having effective rainfall depth are distributed along the rainy season with maximum intensity of 55 mm/day.

The maximum annual sediment loads took place in 1988 (142.56*10^3, 19.38*$10^3$and 10.15*10^3 ton) for the selected valleys respectively (Figure 4a, band c). This year had the maximum annual rainfall depth of 656 mm and maximum runoff volume for all the valleys.

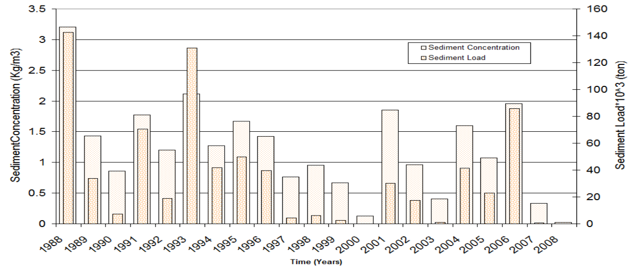

Fig. 4a- Yearly sediment load and sediment concentration of valley-1 for considered period

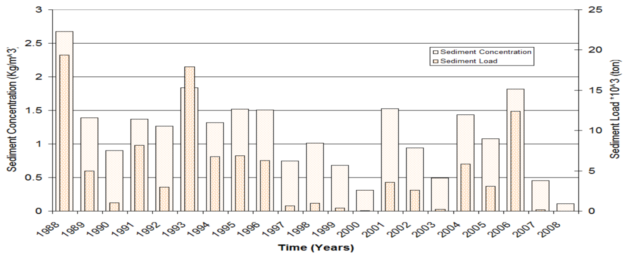

Fig. 4b- Yearly sediment load and sediment concentration of valley-2 for considered period

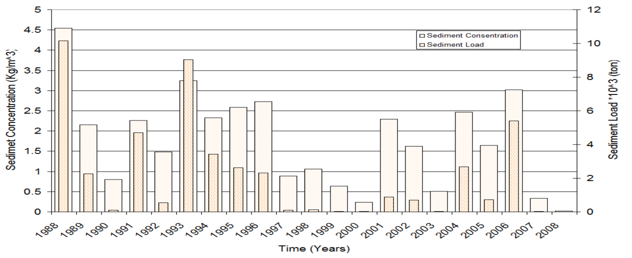

Fig. 4c- Yearly sediment load and sediment concentration of valley-3 for considered period

Conclusions

The Soil and Water Assessment Tool (SWAT-2009) working under Geographical Information System (GIS) was applied to estimate the yearly runoff and sediment load carrying from the main valleys at the right bank of Mosul Dam Reservoir. The simulation of the runoff and sediment load extended for twenty one years starting 1988. The objective is to estimate the total load that was carried with the runoff flow and pour directly in to the reservoir. The results indicates that total annual sediment load entering the reservoir from the right bank valleys have a significant amount. This has negative effect on reservoir storage capacity and different hydraulic structures. The total sediment load of the considered period reaches to 747.5*10^3 ton for valley one, 104.3*10^3 ton for valley twoand 45.9*10^3 ton for valley three. This makes the total volume of sediment deposited within the reservoir (338.8*106) 0.34*106 m3. These values of sediment load must be considered especially for valley one, a check dam in a suitable site may be constructed to store the temporary runoff water for a short period to settle the sediment load and then release the runoff to the main reservoir with minimum load.

References

[1] Yang C.T. (1996) *Sediment Transport: Theory and Practice, McGraw Hill, NY*, 395.
[2] US Department of Interior (2006) *Bureau of Reclamation, Erosion and Sedimentation Manual*.
[3] Srinivasan R., Ramanarayanan T., Arnold G. and Bednarz S. (1998) *J. of the American water Resources Association*, 34(1), 91-101.
[4] Fernandez C., Wu J., McCool D. and Stockle C. (2003) *J. of Soil and Water Conservation*. 58(3), 128-136.
[5] Kim H. (2006) *M.Sc. Thesis*, Colorado State University, Colorado, USA. 2006.
[6] Yüksel A., Akay A., Gundogan R., Reis M. and Cetiner M. (2008) *Sensors*, 8, 1222-1236.
[7] Baigorria G. and Romero C. (2007) *Environmental Modelling and Software*, 22, 1175-1183.
[8] Engda T. (2009) *M.Sc. thesis*, Cornell University, USA.
[9] Gitas I., Douros K., Minakou C., Silleos G. and Karydas C. (2009) *EARSeL e-Proceedings* 8, 40-52.
[10]Nangia V., Wymar P. and Klang J. (2010) *International Journal of Agricultural and Biological Engineering* 3(3), 1-11.
[11]Jain M., Mishra S. and Shah R. (2010) *Currenet Science*, 98 (2), 213-221.
[12]Kim J.G., Park Y., Yoo D., Kim N., Engel B., Kim S., Kim K., Lim K. (2008) *American Society of Agricultural and Biological Engineers Annual International Meeting*., 9, 5282-5287.
[13]Dos Santos D., Andriolo M., Gibertoni R. and Kobiyama M. (2010) *International association of hydrological science*, 337, 322-328.
[14]Doughlas-Mankin K.R., Srinivasan R. and Arnold J.G. (2010) *Current development and application, Transaction of ASABE*, 53(5), 1423-1431.
[15]Mohammad A. (2006) *M.Sc. thesis, University of Mosul, Mosul, Iraq*.
[16]Ashagre B. (2009) *M.Sc. Thesis*, *Cornell Univrsity, New York, USA*.
[17]Winchell M., Srinivasan R., Di Luzio M. and Arnold J. (2007) *Blackland Research Center, Texas Agricultural Experiment Stationand Grassland, Soil and Water Research Laboratory, USDA Agricultural Research Services*.
[18]Chow Ven Te Maidment, David R., Mays, Larry W. (1988) *Applied Hydrology, McGraw Hill*, 277.
[19]Nearing M., Liu B., Risse L. and Zhang X. (1996) *WRB, American Water Resources Association*, 32(1), 125-136.
[20]Chaplot V. (2005) *Journal of Hydrology*, 312, 207-222.
[21]Jassim S.Z. and Goff J.C. (2006) *Geology of Iraq, Dolin, Prague and Moravian Museum, Brno*, 341.
[22]Al-Naqib S.Q. (1980) *Geology of Atrush area. M.Sc. Thesis, University of Mosul, Mosul, Iraq*.
[23]Mohammad E.M. (2005) *A Conceptual Model for Flow and Sediment Routing for a Watershed Northern Iraq, PhD, thesis, University of Mosul, Mosul, Iraq*.