Effect of rainfall change on sediment deposition in Lake Tuni

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1. INTRODUCTION

Lake Tuni provides important water resources to two major cities of Bolivia, La Paz and El Alto. Hence there is a big concern that global climate change will not only accelerate glacier retreat but may also accelerate sediment deposition, reducing the storage capacity of the lake. Therefore, is necessary to estimate the present and future amount of sediment inflow to the lake.

Due to the particular climate conditions of the study area and the type of data available, we consider that one important aspect, for a proper assessment in the matter, is stablish a relationship between the material eroded from the land surface, sediment yield, and the amount which is actually transported into a reservoir, sediment deposition. A second aspect to take into consideration is the analysis of the major parameters sensitive to climate change, in our case precipitation, whose future variation can influence the loss of storage capacity in the reservoir.

Despite there are numerous studies on various aspects of reservoir sedimentation, this two aspects have not been yet clearly addressed. However, certain approaches gave us insights into these processes. Milan et al. (2007) and Hashimoto et al. (2013) proposed new techniques for field surveys that can be linked with the estimation of the rate of sediment deposition. In the studies of Kawagoe (2012), Kothyari et al. (1994), Walling (1999) and Wilson (1973) were exposed the sensitivity of sediment yield to land use, soil coverage, soil formation and precipitation.

Consequently, the purpose of this study is to evaluate the future reservoir conditions of sedimentation based on the effect of rainfall change, considering a proportionality relationship between sediment yield and sediment deposition.

2. STUDY AREA

Lake Tuni is located in the prefecture of La Paz, at the north-west part of Bolivia. The main source of sediment inflow to the reservoir is Tuni River, which originates in Tuni Glacier. Tuni River flows for 5.5 [Km] before draining into Lake Tuni, it has a contributing catchment area of 10 [Km^2] and around Tuni river mouth was formed a sediment deposit, which surface area is 0.035 Km^2 (Fig. 1).

3. METHODOLOGY

Though that the most representative amount of sediment introduced into a reservoir is located in the sediment deposit, around river mouth. Surveys performed directly on these areas can derive in an interesting overview of the reservoir sedimentation processes.

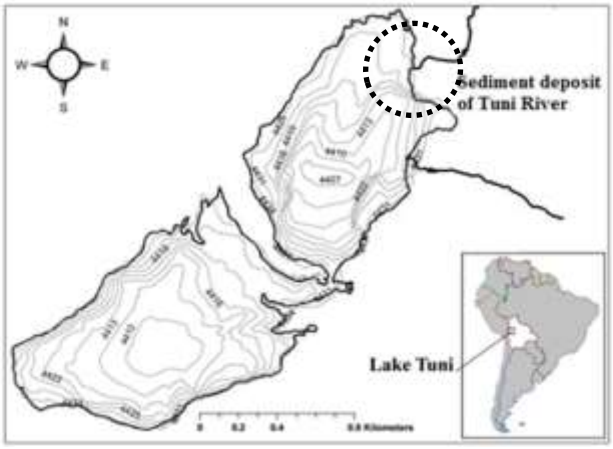

Figure 1. Location of Lake Tuni, Tuni sediment deposit and Tuni River

Consequently, on a previous publication (Sossa et al. (2015)), the rate of sediment deposition was estimated by different methodologies, where the input data came from topographical measurements and fieldwork direct on the sediment deposit, the results are summarized in Table 1.

Table1 Comparison among different methodologies to calculate the rate of sediment deposition (Source: Sossa et al. (2015))

Period	Comp. among topographical inf. [m^3/year]	The Sediment Layer Thickness [m^3/year]	Meyer-Peter and Müller equation [m^3/year]
2012-2013	$1.2x10^2$	$4.6x10^2$	1.9x10^2
2013-2014	$1.3x10^2$	-	-

Concluding that, the best methodology is the “Comparison among topographical information”. In addition, the other two methodologies analyzed support the idea that in general terms the rate of sediment deposition is low.

The results obtained by the “Comparison among topographical information” are fundamental to stablish the proportionality factor between the rate of sediment deposition and the rate of sediment yield, defined by the following expression:

$$Sediment\ deposition = \alpha * Sediment\ yield \quad (1)$$

Where *sediment deposition* is the rate of sediment deposition [m^3/year], α is the proportionality factor and *sediment yield* is the rate of sediment yield [m^3/year].

Results of Sediment Yield were reported by Kawagoe (2014), based on the application of the Universal Soil Loss Equation.

This method can estimate soil erosion rates and is defined by the following expression:

$$A = R * K * LS * C * P \qquad (2)$$

Where A is the potential average annual loss of soil [(ton/m^2)/year], R is the rainfall factor, K is the erodability factor, L is the slope length factor, S is the slope steepness factor, C is the cropping management factor and P is the erosion control practice factor.

4. RESULTS AND DISCUSSION

The amount of sediment deposited to a reservoir depends on the amount of sediment yield produced by the upstream watershed. Thus, applying equation 1, the proportionality factor between the rate of sediment deposition and the rate of sediment yield is set as 0.7, taking into account the results on the comparison among topographical information.

Precipitation, soil coverage, type formation and land use are some of the parameters that are involved in the estimation of the sediment yield, equation (2). Among these, precipitation is a major parameter sensitive to climate change, then, a limiting factor for the sediment particles removal and the fluvial sediment transport. Soil coverage, type formation and land use have favorable characteristics, resistant to erosion processes.

According to Moya (2014) the precipitation in the study area does not follow any future significant trend, but the annual rainfall change is expected to vary between 0.89 and 1.15. Based on this study, Kawagoe (2014) proposed a relationship between the rate of sediment yield and the already mentioned future annual rainfall change. Thus, applying the proportionality factor to the trend line was estimated the future projections of sediment deposition for Tuni river, (Fig. 2).

Thought, that variations in the rate of sediment deposition were estimated for the two worst possible future sceneries: Decreasing and increasing trend. The final results are ranged from 82[m^3/year] to 158[m^3/year], which, in comparison with other studies in many areas around of the world, represents a very low future rate of sediment deposition. In addition both values represent less than 0.0007[%] of Tuni Reservoir useful storage capacity.

5. CONCLUSIONS

The effect of rainfall change on sediment deposition in Lake Tuni was estimated by the application of a proportionality factor between the rate of sediment yield and the rate of sediment deposition,

The final results for the future rate of sediment deposition, worst sceneries, ranged from 82[m^3/year] to 158[m^3/year] are values that represent less than 0.0007[%] of Tuni Reservoir useful storage capacity; therefore, they do not have an remarkable impact on the loss of storage capacity of the reservoir.

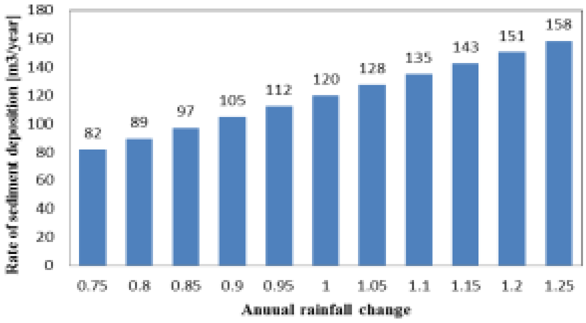

Fig. 2 Relationship between the rate of sediment deposition and the annual rainfall change for the future climate condition

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