# Analysis of the sediment volume deposited in Lake Tuni, Bolivia

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## 1. INTRODUCTION

The amount of sediment deposition to a reservoir depends on the amount of sediment yield produced by the upstream watershed. Despite there are numerous studies on various aspects of soil erosion and sediment deposition, this relationship has not yet been clearly quantified. However certain approaches gave us insights into these processes. Milan et al. (2007) and Hashimoto et al. (2013) proposed new techniques for field surveys to estimate the sediment deposits volume. The sensitivity of sediment yield to land use, soil coverage, soil formation and precipitation were by Hippe et al. (2012), Walling (1999) and Kothyari et al. (1994). And Kawagoe (2012) reported the current sediment yield of Tuni catchment area. Thus in this study, considering all of these patterns, was made an analysis of the sediment volume deposited in Lake Tuni.

## 2. STUDY AREA

Lake Tuni is a precious water resource that provides water 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 it may also result in accelerate sediment deposit, reducing the capacity of the lake.

In Lake Tuni there are two sand deposits, the sediment deposit of Tuni River and the sediment deposit of a nameless river, which surface area are 0.035 $Km^2$ and 0.019$Km^2$ respectively (Fig. 1).

Tuni River originates in Tuni Glacier flows for 5.46 Km before draining into Lake Tuni, and has a contributing catchment area of 10 $Km^2$. On the other hand, the above mentioned nameless river flows for 0.94 Km before draining into Lake Tuni, and it has a contributing catchment area of 0.65 $Km^2$.

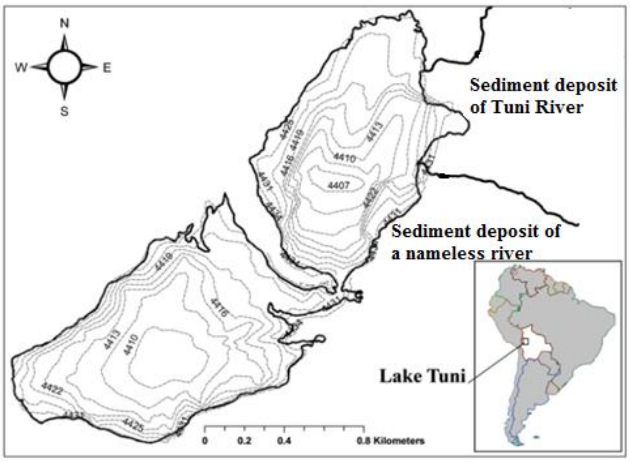


Figure 1. Location of the sediment deposits

## 3. METHODOLOGY

In early October 2013 each sediment deposits was surveyed with a 3D laser scanner, Quarryman Pro, in three parts to reduce the possibility of unscanned areas due to shadowing effect and with a high definition of 0.20 [m] (vertical and horizontal interval between each observation). The instrument combines reflectorless laser measurement technology with high-speed automatic robotic surveying to obtain topographical accurate measurements. Later MDL software is used to export that data into Global Mapper format, deriving in a digital elevation model (Fig. 2-3).

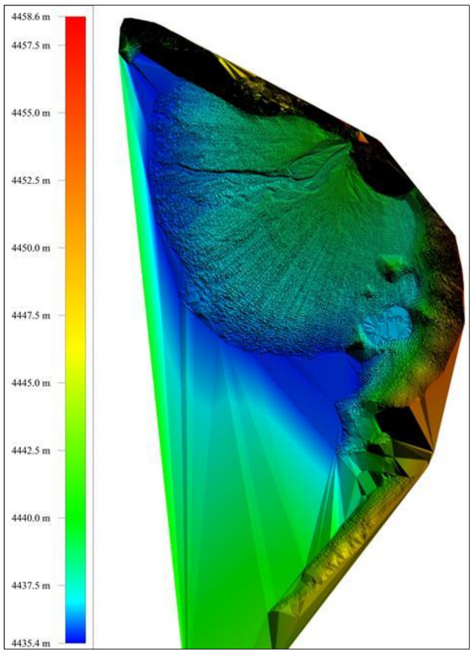


Figure 2. Topography of the sediment deposit of Tuni River

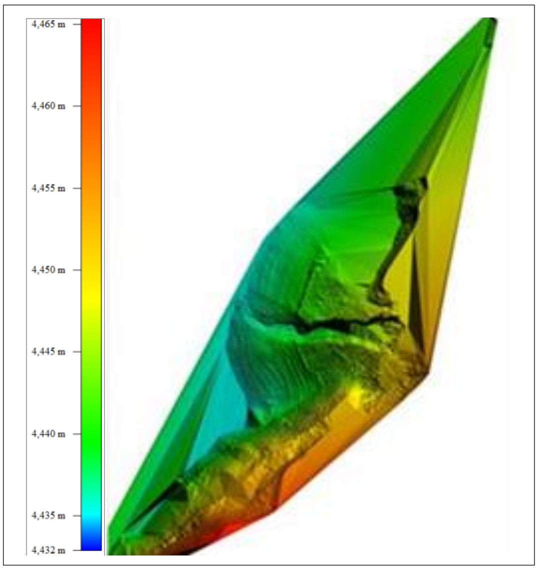


Figure 3. Topography of the sediment deposit of a nameless river

Sediment movement is accompanied by the organization of grains into morphologic elements called bedforms. Thus in this study, through the analysis of excavation points, the bottom level of the sediment deposit is defined as the base over which the presence of bedforms started to be evident. Similar assumption was already validated in the study of Hashimoto et al. (2013).

Therefore 4436.5 [m.a.s.l] is the level assumed as the bottom of the sediment deposit of Tuni River and 4435.9[m.a.s.l] in the case of the sediment deposit of a nameless river.

## 4. RESULTS

Based on the information collected with the 3D laser scanner and with the help of a tool menu in Global Mapper's setup was estimated the sediment deposit volume. The same base height (the bottom elevation of the sediment deposit) relative to each vertex was specified as 4436.5[m.a.s.l] for the sediment deposit of Tuni River and 4435.9 [m.a.s.l] in case of the sediment deposit of a nameless river. These results were summarized in Table 1.

Finally in order to estimate the rate of sediment deposition due to sediment transport by rivers, the total volume of sediment was divided by the length of time that the Dam is functioning of 34 years from 1978 to 2013, showing the results in Table 2.

Table 1 Volume of sediment deposits until 2013 [$m^3$]

| Parameter | Value |
|---|---|
| Volume of Tuni sand deposit [$m^3$] | $4.63 x 10^4$ |
| Volume of a nameless sand deposit [$m^3$] | $3.6 x 10^4$ |

Table 2 Rate of sediment deposition [$m^3$/year]

| Parameter | Value |
|---|---|
| Tuni sand deposit [$m^3$/year] | 1363 |
| A nameless sand deposit [$m^3$/year] | 1068 |

Kawagoe (2012) reported that the current rate of sediment yield of Lake Tuni catchment area is 76.7 $m^3$/year. This a much lower value than our estimations of the rate of sediment deposition, summarized in Table 2. However according to Hippe et al. (2012) the study area belongs to the formation of Paleozoic which indicates a stronger resistance to weathering and erosion processes. Moreover the gradient of precipitation varies monthly from 120 mm in rainy season (Jan-Mar) to 18 mm in dry season (Jun-Aug), which is characterized by episodic, heavy and short duration episodes. Thus the sediment particles removal and the fluvial sediment transport are largely limited to the rainy season. In addition the vegetation on Lake Tuni catchment area is limited to grass and small bushes. This is consistent with results obtained in many different areas of the world, which have already provided evidence that slight land use leads to low erosion rates. Therefore taking into account this factors can be explained the low rate of sediment yield reported by Kawagoe (2012). In the other hand it was exposed the necessity to establish the current rate of sediment deposition by other methodologies.

## 5. CONCLUSIONS

The estimation of the sediment deposit's volume and the rate of sediment deposition was obtained by means of topographical measurements on the sediment deposits (performed with a 3D laser scanner) and information about bottom level of the sediment deposits.

It was established that parameters such as: precipitation soil coverage and type of soil formation are influencing the low rate of sediment yield in Tuni catchment area.

In order to establish the rates of sediment deposition with more accuracy it should be necessary to evaluate other techniques such as the comparison of the current measurements made on 2013 with a future one in 2014.


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