Study on Management and Filling Evaluation of Thana Floodplain Cup with Alluvium and their Influencing Factors

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Abstract

Sustainable management of agricultural systems requires, inter alia, and a functional drainage and irrigation system, which should ensure good drainage of agricultural land but also to guarantee by quantity and quality water for irrigation. The drainage infrastructure in Albania is built on the basis of gravity flow and pumping station system. The drainage-irrigation projects in Albania were developed after the years 50s with reclamation of swamps, as was that of Tėrbuf (Lushnje) with the benefit of thousands hectare result turning on agricultural land. The drainage-irrigation system is designed taking into account the perennial average rainfall regime and analyze the maximum and minimum intensity, implemented with a percentage security of 20 up to 50%. As a result of changes in land use, after the years of 90s, for lack of maintenance and amortisation, the ability of the drainage system has declined in terms of percentage of security with the addition of flood risk which goes over the country up to 130 000 ha , with impacts on the land quality. Water used for irrigation of agricultural plants comes from sources with different backgrounds from rivers, streams, lakes and watersheds which in our country are in significant amounts (over 600 reservoirs with capacity about 560 million m^3) furnished by diffrent resources which vary considerably not only by their qualitative composition, but also the depositions of sediment. Their good management requires for dynamic studies of sediment deposition which is related to their life expectancy and guaranteeing water for irrigation. This study takes into account the level of sedimentation in the reservoir of Thana (Lushnje) with the aim of filling his determination and availability of water for irrigation.

KEYWORDS: reservoir, irrigation water, sediments, floodplain, alluvium

1. Introduction

A sustainable management of agricultural systems requires also a sustainable management of available water resources. Aspects of a sustainable of water use resources should take into account and the vulnerability risks of the agricultural system that may comes from drought phenomena (Loucks D.P., 2000). The solution should be found on the efficiency improvement of strategies and better use of water resources (Vinterfeld S., 2002). A significant part of the irrigation systems are supplied by reservoirs, which have as a major problem the sedimentation (filling their bed alluvium), which depends on the hydrological characteristics of climatic areas where they are located. Based on the carried studies it is known that the deposits of sediment (sand and silt) bring very negative consequences on aquatic ecosystems (Crowe A., Hay J., 2004). Also, sediment storage behind dams can have large implications for ecosystem and coastal development downstream of large river systems, as less sediments are delivered which will influence river and coastal geomorphic processes (Syvitski, 2003; Vorosmarty et al., 2003; WCD, 2000).The level of sedimentation in artificial water basins in time depends on the terrain geomorphologic features, flow rate, the amount of suspended substances but also on the level of surface erosion which significantly is influenced by climatic conditions. The reservoirs also have a significant effect on downstream flows, as they can provide a buffer from flooding by delaying and diminishing flash floods by temporarily storing the excess water (Poolman 2005).The velocity of particulars depositing sediment depends by basin hydrology and flow regime, the rainfall intensities often exceed the soil infiltration rates, leading to surface runoff (Liebe et al. 2005), but also the hydraulic conditions and the type of their administration. The variation in sediments can be attributed to the biophysical characteristics of the reservoir catchments, the nature of slopes, land use patterns, catchment size and methods of measurements (Tamene et al. 2006). Their administration manner regarding sedimentation control determines the longevity and availability of water for irrigation (Di Silvio G., 1996). Filling the reservoir with sediments makes an important limitation of their use and their lifespan. Deposition of sediment causes the reduction of the volume of water collection basin, reservoir capacity and therefore reduces its availability. The annual volume of sediment which are deposited can go from 0.25 mm to 2 mm and more (McMahon T.A., Maine R.G., 1978). Many attempts have been made to find an appropriate sediment management strategies and an optimal strategy is that presented by RESCON (Palmieri et al., 2003; Kawashima et al., 2003). Attempts have been made to develop predictive erosion and sediment models (Lane et al., 2000; Vicente and Confield, 2004; Salas and Shin, 1999; Kaur et al., 2003; Logan et al., 2005; Jain et al., 2005). Application of this model would allow the determination the optimal techniques administration for extending the life of the reservoir. Finding appropriate models for determining the levels of sedimentation in reservoirs and irrigation will determined the optimal routes finding for their administration (Elferchichi A., 2007).

2. Material and Methods

The Thana floodplain is the largest reservoir in our country designed for irrigation of agricultural lands. It was built in 1961 in the Murrizi former marsh (Lushnje). The surface of this reservoir is about 800 ha, with an exploitable volume of 65 million m^3 of designed but which currently goes up to 50 million m^3. Catchment basin is approximately 60 km^2 ha but the main water supply of this reservoir comes from the Devolli river through the Vlashuku dam. The slope of the terrain in the catchment basin does not exceed the 30% in the eastern part but this recliner is less in south-east and more less steep in the southern part. This reservoir has managed within a year about 200 million m^3 of water being recharged up to 3 times. Ability of its irrigation is about 29 270 ha of Myzeqe area. Water goes through the high waters channal (HWCh), right wing, which passes up to 15 m^3/sec, and in half of its length it passes within the city of Lushnja with a length of about 4 km, in which actually are thrown many urban waste. The geological construction of the reservoir and catchment basin is characterized by the poor of groundwater. The reservoir has within it some groundwater resources which have minimum flow but they are very rich in salts that affect its water salinisation. The

ingredients are mostly alveolite rocks and clay dunes. Land for the origin and its transformations are Sandy – Clay (SC). Climate in the catchment basin and its surroundings is characterized by exponential characteristic of the Central Mediterranean climate zone. The average annual temperature varies from 8.2 ^{0}C to 24.4 ^{0}C, while perennial rainfall estimates at the range from 1000 and 1100 mm by year. The main water in Thana reservoir comes from the Devoll river flows and the supply is carried out by maneuvering the gates of the Vlashuku dam in the Kuçova district. Vegetation in this basin it is cultivated and it is represented by agricultural crops (orchards, vineyards and olive trees). On the catchment basin reservoirs of Thana developes their activity the Fier-Shegan, Kosovo and Vogel, Jeta e Re, Çuka etc., villages community, where the entire surface of the basin is used for agricultural purposes.
Hydrologic and hydraulic calculations of the respective water taker represent the basis of the study. A series of topographical and hydrological data are used for the calculations. For the realization of this study was dane the evidentation of the hydraulic elements of the water taker functioning, the security elements (the end discharger, water releaser, water intake determination of hydraulic parameters, the definition arrester of the catastrophic flow with the % security designed) which must afford the full emissions of unpredictable rainfall situation as well as the the irrigation hydro-module definition.
Thana reservoir dam is built with clay soils based on the bathtubs method, technology that was subsequently replaced by the compression method without bathtubs. During the construction on the reservoir dam has been some slippage on the upper biefit as well as by the lower biefit. But similar phenomena this dam has been even also during the period of its functioning. The reservoir releasing water due to the weight and its fragility has been almost non-small decrease in the beginning of its utilization. From the measurements and observations are appear performed distortions in the body of the dam to cession ascertain. In the dam crown are noticed its downs and some longitudinal cracks and slippage in some places in escarpments. The segment of the dividing reinforced concrete built in 1998 in prog.00 to 50 ml is reduced at about 30 cm. This situation has dictated that the water level in the reservoir to maintain a regime controlled by filling up 2 m below the normal level of utilization. In dam body it is noticed some eroded segments coused by surface waters and erosion. The descending of the water discharge on the body of the dam does not functioned. This has caused that the torrential rains follow their path by creating conditions for slippage on embankments. Base formation during the construction of the dam is flysch, with brown shales combination, coupled with thin sand layer and anrelite rare.

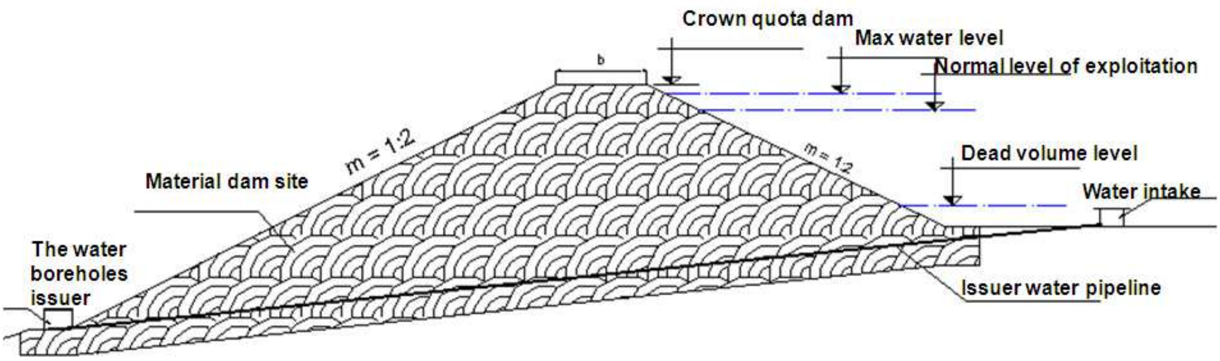

Figure 1. The dam cross section of the Thana reservoir

The operation of the dams with local material as in the present case requires specific technical conditions and a correct mode of storage utilization levels. It is built to withstand large water flow levels which are calculated (design phase) with the respective security by % levels (1%, 5% and 20%). In cases where this safety % is exceeded (ie water flows not covered by elements of discharge), water spill happens over the crown and it is associated by body deformation of the dam until its cracks. For this reason, this dam constitutes a potential risk of residents who lives below it.

The dam provides water discharge with 1% maximum security (repeating one time in 100 years) to a maximum level in quote + 32.9^{00} by forwarded a flow up to 25 m^3/sec. In recent years this reservoir was built concrete parapet with H = 1.2 m but technically it is not playing a big role as the quota of water in the reservoir is kept controlled because of dam defects that have to 2-3 m below the normal utilized level.

The catastrophic discharger is one of the most important elements to discharge excess water reservoir in case of big flows. It enters automatically at work with the rise of water level and is an open section of the channel, with larger threshold before the dam. In the case of Thana dam reservoir this watershed has control of the feeder or water supply because it takes time to control water from the Vlashuku dam on the Devoll river however at the end of the dam in the southern part of the reservoir is built a small size channel for security check but in the project it is not mentioned that this channel serves as a catastrophic discharge. Its function belongs more to discipline the surface waters in the event of heavy rainfall for non erosion in the dam body.

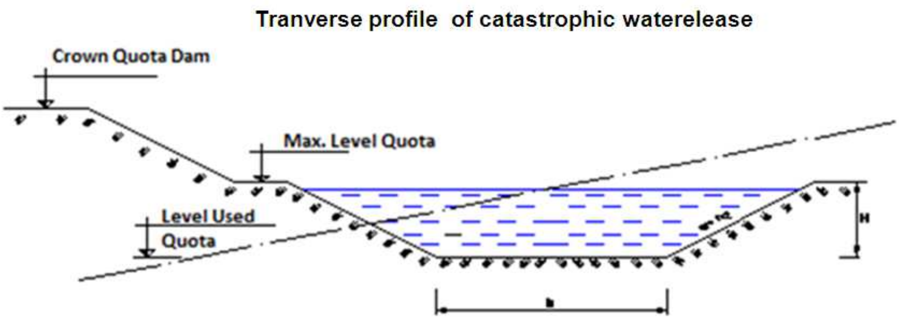

Figure 2. A transverse profile of the arrester type of channel catastrophic levels associated with filling with water

It should be noted that the placing of water channels in the body of this reservoir dam are significant vandalized and their non functioning has created problems in the body of the dam.

As a furnisher for filling his water sources serving two small water flow which is located in the reservoir cup and have quantities salts that affect the quality of water reservoirs of Thana. The amount of accumulated water from these sources is greater during wet months of the year.

The relising water is another very important element of hydraulic reservoir operation and its safety. It provides the passage of water from the reservoir to the main irrigation channel, and is commanded by valves (gates) maneuvering for the issue of water.

Through it is made possible the transfer of a large part of suspended solid materials that move along with the water. On the bottom of it is powered boreholes of relising water and then some energy thresholds extinguishing water. In order to guarantee the repair in case of a fault or avarie in the moments inspection, are noticed that the doors are not fully closed but had considerable flow of water up to 100 l/sec as a result of depreciation. The relising water is the regulator regime of reservoir levels. It can convey up to 20 m^3/sec of water a maximum aperture.
Flow rate obtained from relesed water is divided into two branches one is the branch of Lushnja and the other branch of Krutja. At the exit of relesed water it is constructed the water collection tank and the exit water in the main channel is free to flow away and after 100 m is again an verge of extinction of water energy. It is dimensioned according to the channel hydraulic calculations to convey a maximum flow of 10 to 15 m^3/sec.
The irrigation hidromodul is specific flow rate in l/sec per 1 hectares that is needed for plants provided in agriculture surface which need to be irrigated. The hidromodul is given by the following formula:

$$q = \frac{\alpha \times m}{86.4 \times t} \quad [l/sek/ha]$$

where:

q - irrigation hidromodule
a - is the part of the irrigated plants [ha]
m - irrigation rates on m^3/ha
t - periods of irrigation per day
86.4 - coefficient of return flow m^3/ha in l/sec ha

In view of the objectives the study is divided into two phases from the period of reservoir construction until 1982 on which has become the alluvium filling surveyed by the former Land Study Institute and the second period that goes up today. The second period is based on hydrological and topographical data which are used by several empirical methods, graphical and analytical, based on contemporary foreign literature, to arrive at an accurate determination of reservoir alluvium revestings.

3. Results and discussion

a) Evaluation of filling with alluvium from the period of construction until 1982

The existing data monitoring baseline are taken from the period of construction in 1955 until 1982, by exploiting updates over the years and changes in the reservoir footwear attended a working process monitoring field character, planner and estimator that these packed surfaces Cup reservoir. The study was conducted rikonicioni terrain, updating topographic field and processing (estimates and definition of filled surfaces).
According to hydrological data, the Devolli river at the closest point to Vlashuku channel (Kozara station), has an annual average flow of 10 ÷ 30 m^3/sec of magnitude of 0.01 mm ÷ 0.2 mm.

Table 1. The amount of flow in the Thana reservoir

Size of solids incomes mm	Percentage %	Type of flow
Till 0,01	45	Clay
0,01÷0,05	18	Silt
0,05÷0,1	19	Sand bedding
0,1÷0,2	11	Petite
0,2÷0,5	4,5	Medium
0,5÷1,0	2	Coarse sand
1÷2	0,5	

From study of the year 1982 done by the surveying sector of the Institute of Land Study which has defined the volume of sediments filling the Thana reservoir since the period of construction in 1955 counted a total of 13.1 million m^3 of sediments. The total volume of the reservoir in the year 1982: 65 million m^3 - 13.1 million m^3 of sediment = 51,900,000 m^3.
Based from the time building up to 1982 have passed 27 years and have a total volume in the reservoir of 51.9 million m^3.

b) Assessment of filling with alluvium and the lifetime of the Thanes reservoir

To determine the filling with alluvium during the second period were used some graphical calculating empirical methods where a special importance is given to determining the stored sedimentents coefficient in the reservoir cup (TE) expressed in persentage. The empirical methods on the prediction of stored sediments coefficient in the reservoir cup are based on collecting data monitoring stations built in a considerable number of diffrent reservoirs and expressing them in the empirical and graphic forms. Brune (1953) presents a graphical method based on observations of some reservoirs in USA using the capacity of the reservoir relationship with annual flow that enters in the basin (TE - sedimentents coeficient of reservoir cup expressed as a percentage, C - volume capacity of reservoir and Qin - annual flow enters in the basin).
We abscissa is the coefficient of sedimentents (TE) which must determine the function of reservoir capacity report and annual flow entering in the reservoir. Sediments deposited in the reservoir (Sd) are calculated taking into account the average value of the erosion inside the watershed basin and sediment transport ratio (SDR) and the coefficient of sedimentents stored in the reservoir cup (TE) through the Brune curve (1953).

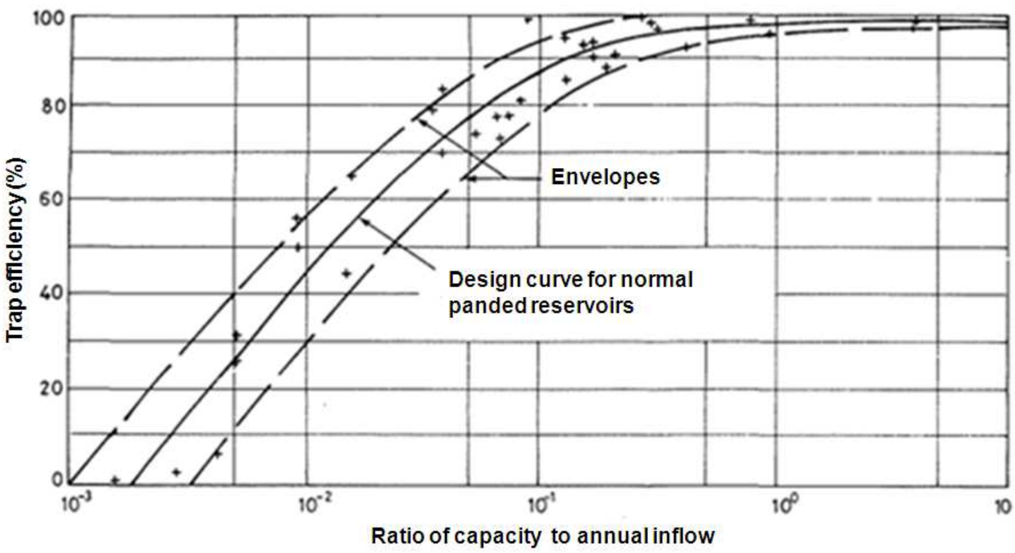

Figure 3. Determination of sediment deposited in the function of reservoir capacity report and annual flow entering in reservoir under Brunet curve (1953)

Based on the designed capacity of the reservoir of 65 million m^3 and the volume of water that enter in the basin of 200 million m^3 define, through graphic methods, the stored sedimentents coefficient (TE) and sediment transport ratio (SDR). From the report of the reservoir capacity with the volume of water that is used during the one year determine the coefficient of deposit sedimentents TE. Capacity / Volume water entering the basin is 0.325. By curve Brunet is 96%.

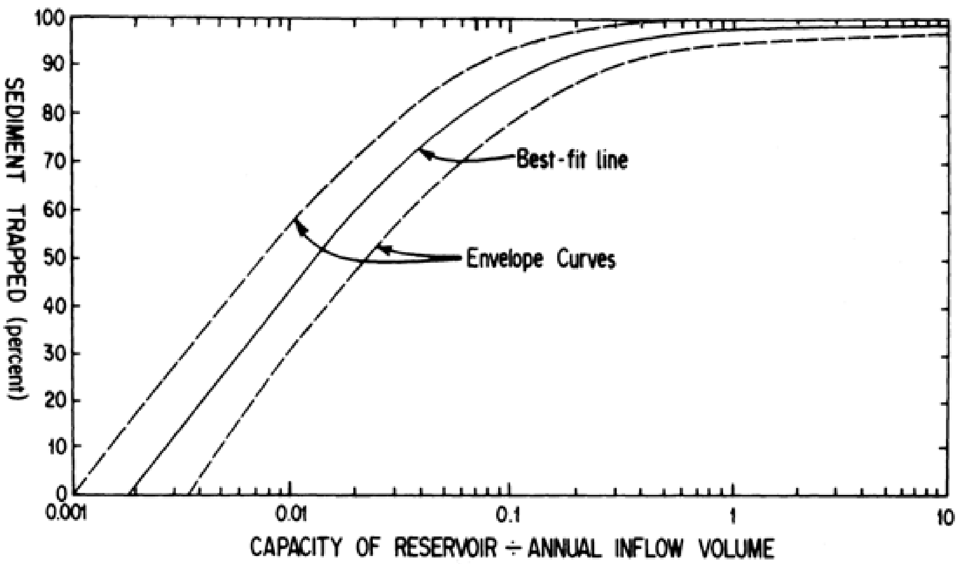

Figure 3. Graph of determination for stored sediments in function of the capacity report and annual flow for Thana reservoir

In the function of the basin watershed surface define sediment transport report. SDR - 00:16 sediment transport.

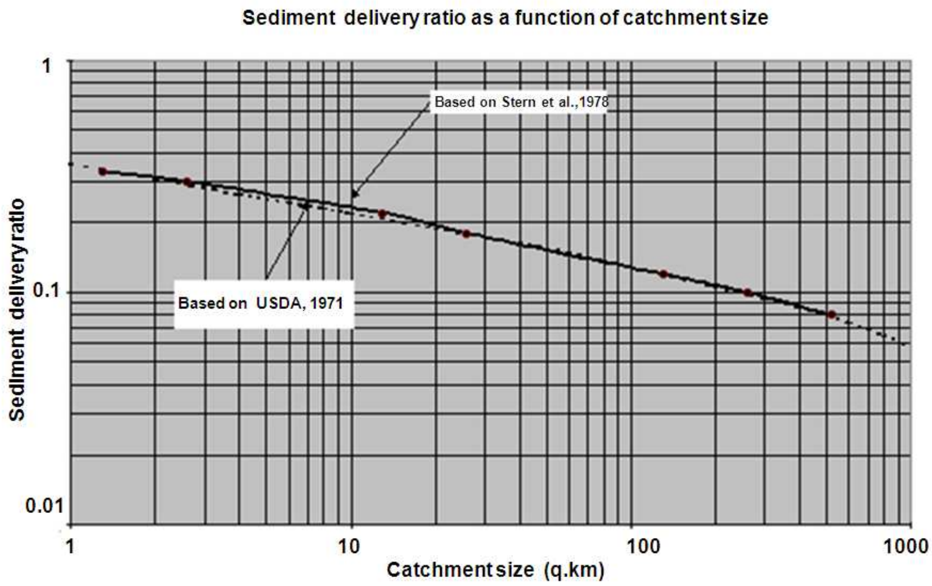

Figure 4. Determining graph of the ratio of sediment transport SDR

The Devoll River carries an annual average flow of 10m^3/sec in the reservoir and a solid flow of 56 kg/sec in watershed basin including the erosion of sediments in the area of the watershed.

Sediments are for watershed basin in the area of 60 km^2.

SB=(60x60x24x365)sec x 56 kg/sec=1,766,016,000 kg/year x 0.001102 =1,946,699.41 tons/year

1,946,699.41 tons : 1,3ton/m^3 = 1,497,461 m^3/year

Sediments deposited inside the reservoir:

$S_R = S_B$ *x SDR x TE =1497461 m^3/year x 0.16 x 0,96 = 472074,6 m^3/year*

Annual loss in % of water volume capacity of the reservoir:

*= (472074,6 : 65 000 000)*100 = 0,72% per year*

Refering last relevance in the 1982 until 2008 have gone full 26 years. Filling with alluvium of the reservoir cup during these years is defined as follows:

472074,6 m^3/year x 26 years =12273940 m^3

The total volume for the year 2008 will be determined as the difference of the total volume available in 1982 and sediments deposited during these 26 years.

51 900 000 - 12273940 m^3 sediments = 39 626 060 m^3

The remaining years that the reservoir should need to filled with sediments starting from 2008 is determined as follows:

39 626 060 m^3 : 472074,6 m^3/year = 84 years

The reservoir will be filled full in all its surface sediments in the year:

2008+84 = 2092

In the graph maner it is shown the difference in the volume of the reservoir during these reservoir using periods by taking as reference base the watershed quota.

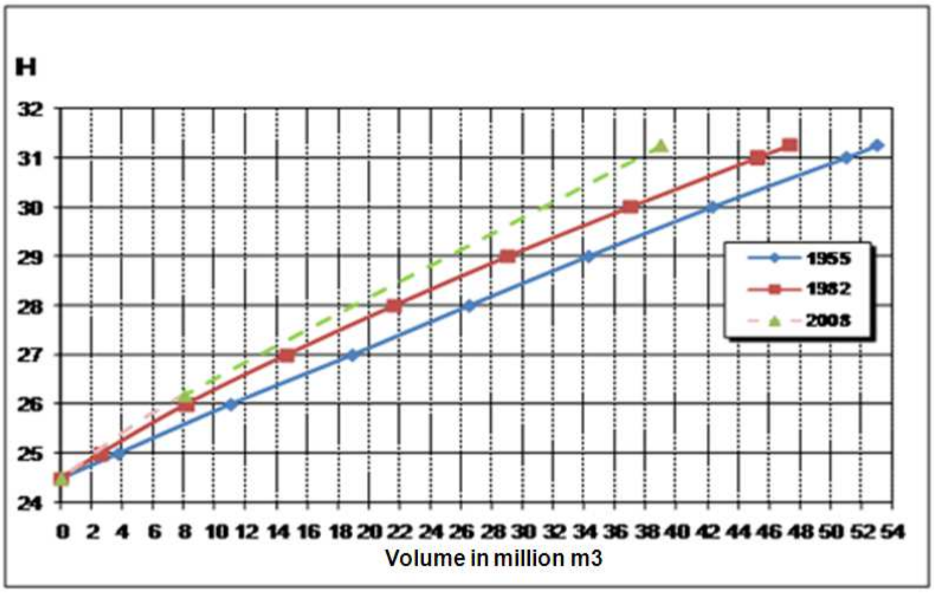

Figure 5. Graph of the water volume over releasing water

4. Conclusions

The study shows that for keeping under control of the alluvial sedimentation of Thana reservoir should be kept under control the maximum water discharge on that should be taking in acount:

Floods of the watershed streams, usually occurring during the autumn-winter-spring months. Floods usually come immediately and their peak happens for a relatively short time.

During the study period there were not observed floods because there were not any of them but they are studied starting from the 1950s, which brought full large quantities of water. These floods will go through the dam dischargers with different levels of water, mainly keeping the releasing water open but also maintaining the catastrophic discharger on alert situation.

Floods are associated with very turbulent waters containing considerable suspense and alluvium fans in the form of gravel that is transported over the reservoir bed. The water Supply carries solid flow and alluvium suspended because the Devolli river waters are the most turbulent rivers of our country.

Operating the gates of water receiving towers on the reservoir cup, at the moment of "*critical rain*" becomes cases for blocking the water intake in the reservoir cup by the solid materials transportation.

Rinsing of the upper side from the ending alluvium is carried out by the terminal discharger.

The discharges control should be carried out during the flood passes in the autumn-winter-spring and during the irrigation periods.

The discharges gates observed should be continued and maintenanted immediately after any kind of demages.

Finding suitable method of study would help in determining the right level of sedimentation and measures for keeping them alway under control.

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