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Discussion And Concluding Remarks On The Feasibility Of Sluicing Operation In Hydro-Power Dams

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ABSTRACT- *With the increase in water demand for various purposes, the output of the reservoirs is a valuable resource. However, a natural phenomenon such as sedimentation, which cannot be eliminated completely, decreases this output. Not only do the sediments decrease the reservoir capacity, but also destroy the machinery such as turbines, etc. Various methods have been brought forth to scour the sediments from the base of the reservoir but not many of them are feasible enough to be applied.*

Out of all the available methods, sluicing may be considered as an efficient method. Although sluicing may also cause disastrous effects on the downstream side if not carefully monitored, however the disadvantage is less as compared to the conventional flushing. The perennial availability of a minimum head in sluicing not only makes the process fit for reservoir conservation but keeps the power output steady.

This paper discusses the feasibility of sluicing based on an overview of the previous findings on the subject and presents concluding remarks so as to optimize the operation of sluicing in practical situations.

KEYWORDS- *flushing, sluicing, scour cone, sedimentation management.*

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I. INTRODUCTION

As far as the hydro power generation capacity is concerned, India produces 39324 MW (18.6%) out of which 78% lies in the Himalayan region. Thus, the Himalayan regions provide regions of untapped hydro potential. (IOSR-JMCE e-ISSN: 2278-1684).

The sediments in the Himalayan rivers are carried by mass weathering where the fine sediments move quickly while the larger ones are slower in their pace. The Ganga river annually erodes around 749 million tonnes of sediments, mostly from the Himalayas, brings about 729 million tonnes at Farrakka and finally dumps 95 million tonnes in the Bay of Bengal. Ganga at Haridwar and Yamuna at Allahabad are chachterised by low sediment yield of 150-350t/km^2/yr, while eastern tributaries like Kosi and Gandaki carry a much higher sediment load of 1500-2000t/km^2/year. The rivers of the Ganga basin carry one of the largest sediment loads in a year. Silica weathering rates and the release of radiogenic Sr are higher in the Siwalik foreland sediment basin sediments and floodplain, although still poorly known. (Nitish priyadarshi).

Sedimentation hampers the productivity of a reservoir on a Himalayan river by substituting the space available for water by sediments. Although sedimentation is a phenomenon common to every reservoir but due to the enormous load carried by the Himalayan Rivers, the havoc caused is immeasurable.

Available Methods To Counter Sedimentation

There are various methods in use for sediment management which either target the minimization of sediment deposition or removal of sediments from reservoirs. The various methods have been discussed as under:

i. Sediment bypass: This method involves the diversion of the sediment laden flow by means of canals, tunnels or pipes. Canals and pressurized pipes are not used as frequently as canals due to problems in laying them. These structures are generally used in Switzerland and Japan due to their mountainous terrain. Nunobiki dam in Japan has been maintaining its storage capacity by use of this method.

However one of the main problems faced in this method is the abrasion caused by the water at the inlet which can probably be prevented by using a layer of high strength concrete or likewise during the design.

ii. Sluicing:This method involves the decrease in the reservoir level and the sediment bypass through the sluice gates. The pattern formed by the incoming sediment is deltaic wherein larger particles settle first followed by the smaller fines. Sluicing aims at minimizing the formation of this delta. According to a 1998 assessment, the height of the sluice gates must be 1.5 to 2.5 meters and that the width of the gates must be changed to increase effectiveness [4].

iii. DensityCurrent Venting: This method involves the discharge of the sediment laden water from low level outlets. It is based on the generation of a density current. Turbidity currents develop when water with a high sediment load enters a reservoir and immediately plunges to the bottom, travelling through the original channel until settling under the dam in a muddy pool (Morris and Fan). However, density currents form under certain conditions and are difficult to detect. Under optimal conditions, approximately 50% of the total sediment can be ventedthough the average is closer to 20% since early detection methods are lacking (Utah Division of water resources, 2010).

iv. Flushing: It may be drawdown or pressurized.

1) Drawdown Flushing: It is carried out during the pre or post -flood season during which the water level is low. This is one of the main difference between flushing and sluicing.
2) Pressurized flushing: Pressurized flushing removes only a fraction of the sediment and mainly clears the area occurring immediately. (Annandale, 2013). The area formed after the flushing is that of a funnel-shaped crater called as flushing cone (Emmamgholizadeh et al., 2006).

v. Dredging: An expensive but effective method, dredging comprises of removing the sediments by means of hydraulic buckets, pumps, etc. However dredging one of the reservoirs in a state could cost more than 100 times the original amount invested in constructing the reservoir (Baker, et. al, 2008).

Audit Of The Current Methods

i. Sediment bypass- This method does not interfere with the regular functioning of the reservoir, as drawdown of water level is not needed. However the method is difficult to apply and cannot be used in water scarce areas [5].

ii. Sluicing- In this method, a minimum head is always maintained for the operation of the hydro power plant. If not monitored properly, this method can create havoc on the downstream side.

iii. Density Current Venting- This method is rarely used as the detection and formation of density currents is not certain.

iv. Flushing- There is an ecological impact due to flushing, be it drawdown or pressurized. The applicability of the method can be summarised as:

Drawdown flushing- This method is effective in narrow, gorge-shaped reservoirs and water must be allowed to be fully drawn down, making it near impossible to implement in hydropower dams [5].

v. Pressurized flushing- Fish densities can decrease due to flushing. Sediments also affect the downstream infrastructure such as clogging of canals, wearing out of turbines, etc. [1].

vi. Dredging- The method is very expensive, hence uneconomical. Contaminated silt which is dredged out can cause pollution. However, eutrophication is reduced which results in the progression of the zooplanktons to a less eutrophic balance (Zhang, et. al., 2009).

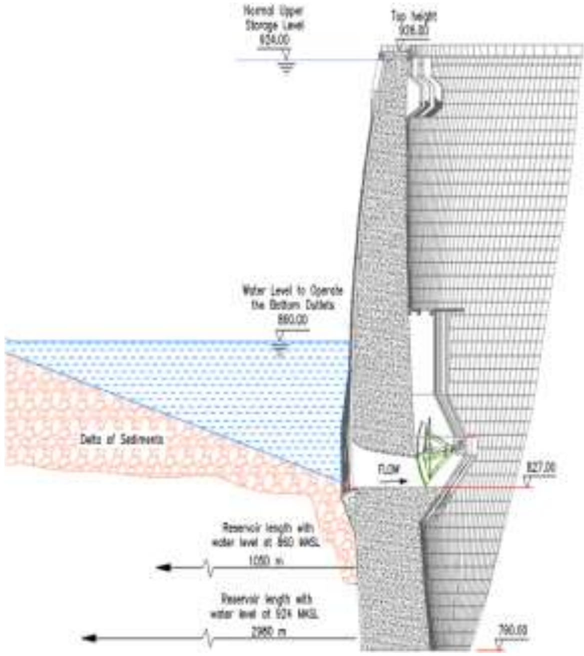
II. SLUICING PROCESS

As mentioned earlier the sediment deposition in reservoir forms a delta. The coarser material deposits first followed by fines. The rate and magnitude of this deposition may vary from one reservoir to another.

In mountainous reservoirs, the larger size particles create greater hindrance in comparison to the smaller deposits which in fact are 5 times the amount of the former. The gravel and sand particles settle close to the operational level. Furthermore, these sediments cause rise in the water level which is dangerous during the flood season. Also, there is erosion on the downstream side due to the lack of larger particles to maintain the equilibrium.

One of the possible solutions to counter this problem would be excavation but that would only solve half the problem. It, on one hand would remove the sediments but would be of no help to replenish the eroded bed on the downstream side.

Another solution that can be presented is the discharge of the sediments using the hydraulic energy of the flow by discharging this water through sluice gates. The latter has been explained in detail in the subsequent discussion.



Principle- If the water level is reduced, the reservoir is full with sediment laden water. If as such the sluice gate is opened there will be discharge of the sediments.
However the reduction is water level causes loss of water. Therefore, drawdown and sluicing time must be minimized.

The drawdown for sluicing can be mathematically given as:
$\Delta H = H_0 - q_r/v_{Rc}$ equation 1 [2]
Where
v_{Rc} = flow depth in the reservoir
q_r= discharge per unit width in the reservoir

Scour Cone

During sluicing, a crater like structure is formed on the upstream side due to the removal of sediments. In order to attain equilibrium, water from the bottom of the intake will get released through the bottom intake and a funnel shaped crater will be developed with an angle of repose of the sediment. Once this cone is formed and no more sediments are flowing into the cone, the water flowing in this cone will be removed.
This scour cone, thus helps to reduce the sediment concentration near the entrance and thus reduces abrasion.

III. DISCUSSION AND CONCLUSION

One of the major problems that engineers are going to face in the future is the replenishment of exhausted reservoirs. Besides, sediment load being the major reason, another cause of the afore-mentioned is the lack of data. Lack of data results in the non-existence of a sediment management project.

Sediments, being the major reason of encroaching reservoir life cannot be eliminated completely. Many of the existing methods are inapplicable because of them being uneconomical (dredging) or having an uncertainty in function (density current venting). Flushing being one of the major method used for reservoir conservation is flawed due to the following reasons:

a. The water level is dropped below the power intake level and hence power generation is stopped.
b. Drawdown flushing requires the complete drawdown of the reservoir which is not practical.
c. Flushing disturbs the aquatic life such as fish, etc.
d. Pressurised flushing results in the abrasion of turbines, clogging of irrigation canals, etc.

Therefore, sluicing could be one method which could meet the goal of reservoir argument. But before an overview of sluicing, the requirements of a hydro power dam in the mountainous reservoirs is discussed in the following points:

a. Continuous supply is required to generate power which is not achievable by flushing.
b. The sediments discharged should cause minimum damage on the downstream side.
c. The water level should not go below the MDDL i.e. the minimum drawdown level.
d. There should be an equilibrium between the inflowing and outflowing sediments. [3]

Feasibility Of Sluicing:
Sluicing is most efficient for gorge shaped narrow reservoirs. Some of the design parameters to be considered have been discussed in I (part ii).
Furthermore, Bogardi suggested that sluicing is effective when:

1. Water depths are low and discharge is high.
2. Sluice gates are wide and located near the bottom of the dam.
3. The original stream bed is steep and reservoir has short, straight bottom.
4. The reservoir is in an advanced stage of siltation and the deposits consist of fine grained recently settled material [6]

Thus sluicing can be implemented in the mountainous reservoirs due to the advantage that it provides a minimum head for operation of power plant. Moreover the sediments are kept in suspended form which get discharged from the sluice gates. Thus for reservoirs meant for power generation, sluicing can be used effectively.
Furthermore under careful monitoring, downstream effects of sluicing can be reduced.

REFERENCES

[1]. Kathleen M Healy, Amanda L. Cox, Daniel M. Hanes and Lisa G. Chambers. "State of the practice of sediment management in reservoirs: minimizing sedimentation and removing deposits".
[2]. Helmut Scheuerlein. Sediment sluicing in mountain reservoirs.
[3]. Abhijit Lade, Pritesh Jivani, Raj Gandhi, Darshan Jain, Siddharth Gawade and Devang Bhurat (2015). Feasibility of sluicing operations for run-of-river schemes in Himalayan region.
[4]. Paul, T.C., and Dhillon G.S., (1998). "Sluice dimensioning for desilting reservoirs," International Water Power and Dam construction, 40(5), pp 40-44
[5]. Tigrek, S., and Aras, T. (2011). Reservoir sediment Management, CRC press, Leiden, the Netherlands
[6]. Bogardi, J. (1974). Sediment Transport in alluvial streams, Budapest, Hungary.

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