Tackling the growing problem of sedimentation

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Worldwide experts will convene in South Africa in September 2010. At the top of their agenda is the growing problem of river sedimentation. Professor Gerrit Basson explains why tackling this issue is of great importance to the dams industry

Large dams have been constructed worldwide at a rate of 1.2 dams/day since 1930, based on the dams registered on the ICOLD World Register of Dams. Many of these structures will continue to fill up with sediment as they age.

High rates of sedimentation in many reservoirs and better care of long term sustainability have emphasised the importance of reservoir sedimentation. The main problems which can be encountered include: loss of storage; damages to turbines and loss of hydro power production; and downstream impacts.

The total world reservoirs storage is about 7000km^3 (6100km^3 based on the ICOLD Register of Dams, but if smaller <15m dams are included, 7000km^3 could be the current total storage). About 3000km^3 of this is dead storage for hydropower. Of 4000km^3 of live storage, most of this is devoted to hydro power and about 1000km^3 to irrigation dams, potable or industrial water storage; part of which is in multipurpose dams.

The annual sediment load of the world's rivers together is estimated to be between 24-30B tons for a water inflow of 40,000km^3, ie an average sediment content of 0.6-0.75T/1000m^3 of water but it varies enormously according to the river and to the discharge. All rivers are not dammed and all sediments are not trapped in reservoirs: the accumulated sediment storage in world reservoirs has been evaluated as 1400Mm^3 for 30 to 40-year-old dams on average, ie in the range of 40Bm^3 per year, ie 0.6 % of the total storage per year.

The historical growth in storage capacity up to 2010 based on the ICOLD World Register on Dams, and historical and predicted reservoir sedimentation is shown in Figure 1a.

Most sedimentation is at hydro power dams, partly in dead storage but the loss of power supply is however not proportional to the loss of live storage. The annual loss of power supply appears in the range of 0.5% of a total investment of about US$1000B for live storage, ie US$5B per year. As hydro power reservoirs silt up however, they have to be replaced by new dams eventually at a cost of the total storage capacity (dead and live) and at a total investment of US$1700B, the annual cost of replacement is 0.6% x 1700 = US$10B/year.

The annual loss of storage of irrigation reservoirs, possibly 7Bm^3, impacts directly on the irrigation capacity; for an investment of US$0.2-0.5/m^3 for reservoirs in excess of 10Mm^3, or up to US$1/m^3 for dams smaller than 50000m^3 (often found in the Indian sub continent and in Africa), with say a global investment cost of US$0.5/m^3 the annual loss may be in the range of US$3.5B. There is also the cost of downstream damages and, for

possibly 5 or 10% of hydropower plants, losses of power supply and cost of maintenance for turbine wear.

The total yearly loss linked with sedimentation problems is thus about US$15B (excluding downstream impacts) and with downstream impacts considered the annual cost is about US$17B. This should however be compared with the annual overall costs and benefits of dams:

• Some US$40B of investments and US$17B for operation, maintenance and upgrading (0.7% x US$2400B; rate usually 0.3 to 0.7%), ie a total cost in the range of US$57B.

• Some US$125B of electric power supply (2500 TWH x US$0.05) and other benefits (especially food by irrigation for over 500 million people).

The total yearly impact of siltation of US$17B should thus be compared with the overall yearly costs (US$57B) and overall yearly benefits (US$175-225B) of world dams. The annual cost of reservoir sedimentation (in terms of replacement cost) is about 30% of the overall costs which is not insignificant. However, much less than 30% is currently spent on sedimentation mitigation measures and the problems are therefore postponed to future generations in many countries.

Potential impacts of storage capacity

Based on the ICOLD World Register on Dams, hydropower dams make up 81.5% of the world's total current storage capacity. In 2006, 35% of the total storage capacity for hydropower had been filled with sediment. By 2050 this predicted proportion of current total capacity that would be filled with sediment has risen to 70 % (Figure 1b).

For dams for any other purpose (non-hydro), in 2006, 33% of the available capacity was filled with sediment, rising to a predicted value of 62% by 2050.

It is expected that non-hydro dams will be severely impacted on when they reach a 70% sedimentation level. At this sedimentation level there will be about a 40-50% water yield reduction, and there could be problems at the intakes. Based on the global data this will occur by the year 2065, and will occur per region as indicated in Table 1.

Hydro power dams can generally be filled with sediment to a higher level than non-hydro power dams, as it is mainly necessary to maintain the head for the power generation, and a storage capacity sufficient to meet all expected demands for power. It is expected that hydro power dams will be severely impacted when they reach a level of sedimentation of 80%. Based on the global data this will occur by the year 2070, and per region as indicated in the table.

Countries that are anticipated to have critical sedimentation volumes by year 2050 are: Afghanistan, Albania, Algeria, Bolivia, Botswana, China, Columbia, Ecuador, France, Fiji, Iran, Iraq, Jamaica, Kenya, Libya, Malaysia, F.Y.R.O. Macedonia, Morocco,

Mexico, Namibia, New Zealand, Oman, Pakistan, Puerto Rico, Saudi Arabia, Singapore, Sri Lanka, Sudan, Tanzania, Tunisia and Uzbekistan.

Symposium on sedimentation

In order to help countries tackle the problems associated with sedimentation, the 11th International Symposium on River Sedimentation (ISRS) will be held in South Africa from 6-9 September 2010. The ISRS is held to bring together scientists and engineers working in the fields of river, lake and reservoir sedimentation, and covers theoretical and practical aspects related to sediment transport processes, including environmental aspects. The impacts of hydraulic structures on fluvial morphology as well as measures to limit the impacts for sustainable development of water resources are also key elements. Other noteworthy areas include a focus on catchment soil erosion programmes, sediment monitoring techniques, reservoir flushing and other techniques to limit sedimentation, environmental aspects including water reserve determination for river ecology.

Keynote presentation topics include:

• Mega deltas and the climate change challenges by Dr Kim Wium Olesen, Head of Water Resources Department, DHI.

• Sediment Data Collection in Rivers, Reservoirs and Lakes by Prof. Dr. Manfred Spreafico, University of Berne, Switzerland.

• Erosion and Sedimentation Research Emphasis in the USA by Dr. Matt Römkens, United States Department of Agriculture (USDA) Agricultural Research Service (ARS).

• An introduction to latest developments in soil erosion and sediment transport modelling by Dr. Weiming Wu, National Center for Computational Hydroscience and Engineering (NCCHE), The University of Mississippi, USA.

• New challenges in sedimentation and erosion research by Professor Zhao-Yin Wang, Tsinghua University, China.

The four-day symposium also includes a technical visit to the recently completed Berg River dam, the first in South Africa where environmental floods are released for ecology, in addition to erosion protection works at Cape Town.

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