International Invention of Scientific Journal
Online ISSN: 2457-0958
Available Online at https://iisj.in **Volume 8, Issue 03 (July-August-September)|2024**|Page: 597-607
Original Research Paper-Engineering

Management of Sedimentation Prevention, Sedimentation and Simulation Models of Dam Reservoir Sedimentation: A Review

Authors:
Ali Soleimani[1], Masoud-Reza Hessami Kermani[2]
[1] *MSc, Department of Civil engineering - water and hydraulic structures Kerman Shahid Bahonar University*
[2] *Associate Professor, Civil Engineering Department, Kerman Shahid Bahonar University*
Corresponding Author:
Ali Soleimani
MSc, Department of Civil engineering - water and hydraulic structures Kerman Shahid Bahonar University

Article Received: 12-July-2024 Revised: 02-August-2024 Accepted: 22-August-2024

ABSTRACT:
The sustainable use of natural resources is very important all over the world. Nowadays, sedimentation and accumulation of sediment in dam reservoirs is an important challenge in most countries and regions of the world. For reservoirs, the loss of storage utilization is a fundamental challenge for sustainable use. There are several management options that can stabilize the dam reservoir and improve its performance, one of which is the removal of accumulated sediments. If reservoir sedimentation is minimized and dams are allowed to remain in operational condition forever, in addition to useful storage and minimizing environmental impacts, economic and social costs will also be reduced. Selecting the appropriate sediment management strategy in each reservoir is important. That is, washing operations has advantages in effective use of river water for sediment discharge. Sediment washing in reservoirs largely depends on the efficiency of sediment washing, and the efficiency of sediment washing largely depends on the geometry of the dam reservoir, the height of sediment washing gates, the volume and size of sediment grains, and the amount of discharge during sediment washing. In general, there are two limiters for the width of the dam during dredging. If the width of the bottom of the dam is small, it will limit the sediment exit channel, and if the width of the reservoir at the top is large, it will cause sediments to remain in some parts of the reservoir and dredging to If it is not done correctly, we can also create a spiral shape before the sediments reach the reservoir or create walls before the flood enters the reservoir to cause sedimentation at predetermined points. In order to carry out effective desalination operations, it is necessary that the general movement of water and sediment occurs in the reservoir. The younger and unconsolidated the sediments are, the more direct the path of the reservoir is in line with the main stream, the smaller the size of the sediments and the steeper the slope of the main river. Sediment washing is done better.

Keywords: sedimentation, dam reservoir, sediment removal, sediment management, numerical modeling.

1. INTRODUCTION:

1.1. An overview of available reviews

Considering the issues and problems that sediment accumulation in reservoirs brings, a lot of research has been done to solve this problem. The studies and research conducted in this direction have led to solutions to solve the problem of sedimentation in the reservoirs of dams, each of which can be used depending on the location of the region and some other parameters. The design and sustainable operation of dams is important. It is high, but during operation, we will face different challenges, one of which is sedimentation in the reservoir of the dams, which leads to the loss of the storage volume of the reservoir, the increase in the load on the dam through sediments, as well as passing sediments. Given, it causes wear of hydroelectric equipment or blockage of inlets, as well as eco-morphological changes in rivers and downstream coasts. Kandolf (1997) has described that if the flow is released from the dams, the change in the main flow regimes and sediment loads caused by the release of dam reservoir water can cause changes in the shape and processes of the river, including flow, water quality, temperature, sediment regime, slope and the river bed is downstream. Sediment management in reservoirs is classified in three ways:

1. Reducing the sediment input to the reservoirs
2. Reducing sedimentation in the reservoir
3. Removing sediments (washing) accumulated in reservoirs

Sediment deposition in the above-mentioned reservoirs takes place in the following forms: the formation of a delta upstream of the reservoir as a result of the sedimentation of coarse-grained materials in the river flow, the settling of fine-grained sediments near the dam body, and dense sediment flow towards the dam body. Each of the aforementioned situations in the reservoir will bring problems and damage, including: reducing the storage capacity of the reservoir, increasing evaporation from the surface of the reservoir due to the increase in the water level of the reservoir, disrupting the flood control activity due to the reduction of the useful volume of the reservoir. The rise of the water level in the reservoir and the flooding of the land around the dam lake, the rise of the underground water table and the silting of the land around the dam lake, the sediments entering the water intake of the turbines and, as a result, the blades of the turbine are worn, the sediments entering the seams related to the valve in the body. The dam, which disrupts the functioning of the intake tunnel valves and the intake valves of the valves below the dam, the entry and deposition of sediment in the intake tunnels and channels, which reduces the transfer capacity and causes damage to these structures.

Background Research:

Several studies have been conducted regarding sediment discharge from reservoirs, among the most important of which the following can be mentioned:
Atkinson 1987, 1992 and 1995, Morris and Fenn 1997, Olsen 1999, White, 2001, Kandolf 1997 and 2014.

1.2. The objectives of this review article and research questions

The purpose of this article includes the following:
1. Examining management options to prevent sediment deposition and de-sedimentation from the dam reservoir, providing different solutions used to solve the problem of reservoirs involved in sedimentation and related operations, the effect of sediment washing on the sediment balance of the river and the physical effects of the environment
2. Examining the physical and numerical models that are used to simulate the descaling phenomenon and predict its efficiency.

The research questions are:
1. What is the cheapest and most efficient method of sediment removal and dealing with the problematic phenomenon of sediment accumulation in reservoirs and dams?
2. What are the most important parameters affecting describing efficiency?
3. The method of removing sediments by completely draining the reservoir water by opening the valves in which reservoirs is the emptying more effective? Why?
4. What method can be used to understand the transfer of sediment in a reservoir, estimate the volume of sediment discharged by desalination operations and temporal and spatial changes of the reservoir level?
5. In comparison with laboratory studies, what are the advantages of preparing a numerical model?
6. In numerical studies, three-dimensional modeling of reservoir sediment washing is suitable for what type of dam reservoir?
7. What kind of models are used to model the sedimentation process in the reservoirs of large dams? Is 3D numerical modeling suitable for large dams?
8. Provide a numerical model that can take into account the effect of different parameters on the flow field and sediment transfer. Can this model be used in the optimal design of sediment removal channels and output hydrography and the range of reservoir water level changes?
9. Can the numerical model mentioned in question number 6 take into account all the characteristics of the flow effect, such as flow turbulence and bed friction or bed shear stress? 10. Can the numerical model mentioned in question number 6 properly simulate the irregular geometry of the river bed and reservoir bottom, the geometry of the sediment discharge valve?

2. METHODS:

2.1. Methods of reducing sediment input to reservoirs:

Watershed management includes controlling erosion or sediment trapping in the watershed and preventing it from entering the dam reservoir, which are classified as follows:

2.1.1. Create vegetation:

One of these methods is the creation of vegetation, which by planting plants in the catchment area of dams, causes a significant reduction in the transfer of sediments to the reservoir of the dam. Also, the vegetation on the riverside of the house reduces the speed of water flow and causes sediments to be trapped before reaching the reservoir of the dam.

2.1.2. Temporary barriers:

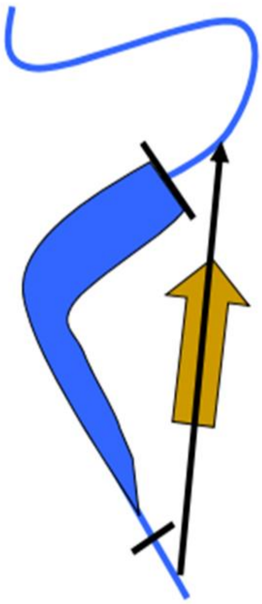
These dams are mostly built from the materials available in the place. These structures are designed to turn the steep slope of the river into a gentle slope and reduce the movement of sediments by reducing the speed of the flow. Are also built, which can be seen in picture 1.

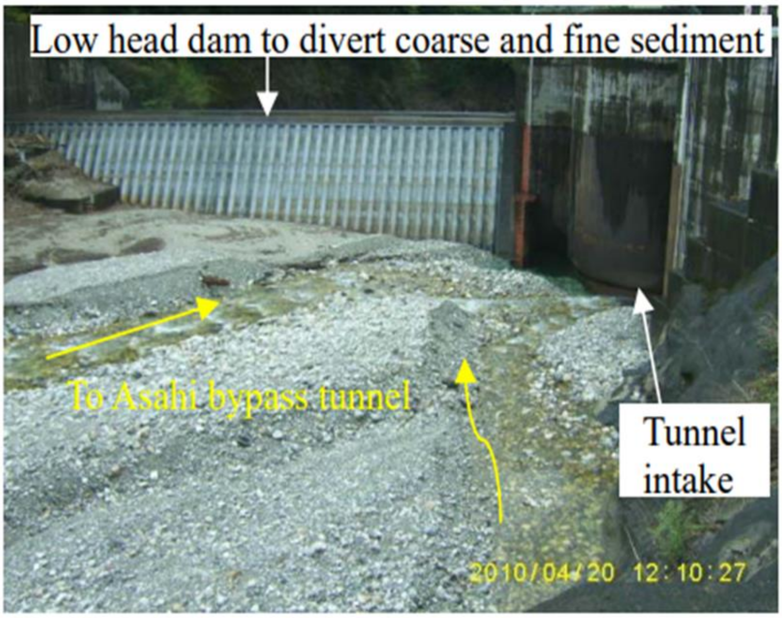
Picture 1

2.2. Methods to reduce sedimentation in the reservoir:

2.2.1. Desalination using the pass tunnel:

Among the methods that have been used in a number of reservoirs of dams is placing the mouth of the tunnel at the entrance of the river to the reservoir and building it downstream of the dam. In this way, during floods, when the river carries a large part of the sediments, the sediment can be transferred from this channel to the downstream side of the dam. With this method, the negative impact of the sediment removal operation downstream of the dam is avoided and the conditions of sediment transfer are almost returned to the conditions before the construction of the dam. Of course, the success of this system depends on hydraulic conditions, reservoir geometry, environmental issues, downstream conditions, and operational issues. However, this system is very effective at transferring non-sticky fine particles. An example of this system can be seen in picture 2.





Picture 2

2.2.2. Describing using the bypass pipe:

The bypass pipe is another way to remove the sediments inside the reservoir. In this method, the sediments deposited in the reservoirs upstream of the main reservoir can be removed through the pipe that passes through the underground valves of the dam. It has been discharged downstream. In the mentioned method, the pipe is placed permanently, and it is suitable to use it to remove sediments (at most the size of sand) by gravity. For more efficiency in this method, the suction pipe must be able to be moved and to ensure the flow speed. It is necessary to install the pump.

2.3. Methods of removing deposits from the reservoir:

2.3.1. Descaling under pressure:

In this descaling method, part of the sediments deposited inside the reservoir are emptied out of the dam through deep valves, and the water level of the reservoir is higher than the valves during the desalination operation. In this method, the sediments are close to the discharge valve and after a certain period of time, a funnel-shaped sediment washing cone is formed in front of the lower Discharger and spreads to the upstream side. The progress of the cone towards the upstream continues until the formed cone reaches equilibrium. The time it takes to reach equilibrium depends on the flow rate of the water flowing out of the lower Discharger, the height of the water inside the reservoir and the type of deposited sediment.

2.3.2. Free hydraulic descaling:

In this desalination method, the water level of the reservoir reaches its lowest level during the desalination operation, so that the river flow is formed inside the dam reservoir. In free hydraulic desalination, the water level of the reservoir is lowered in two stages. First, the water level of the reservoir is lowered slowly and in the second stage the water level of the reservoir is reduced very quickly. It should be noted that this method of desalination is more efficient compared to the sedimentation method under pressure.

2.3.3. Removing sediments by completely draining the reservoir water by opening the drain valves:

This method is used when the sediments deposited in the reservoir cannot be removed by any of the previous methods. In this method, while opening sediment discharge valves for a long-term period (for example, several months) with the action of sediments deposited in the reservoir by the flow, sediment discharge and sediment removal operations are performed. The use of this method is more effective in small reservoirs (diversion dams), because the entire volume of the reservoir is removed from the reservoir as a result of the sediment washing process. One case of this descaling method was used in Hengshan dam reservoir in China in 1984, as a result of which a volume of 13.3 million cubic meters of water was removed from the reservoir in a period of one month.

3. Factors affecting the optimization of sediment removal methods of the reservoir

3.1. Impact of cost and availability of water:

The amount of water used for washing usually exceeds 10% of the average annual input to the reservoir, and water is used both during the washing operation and to refill the reservoir after emptying for washing. Therefore, the suitability of a reservoir for leaching is related to its hydro logical size or storage capacity ratio. If the storage capacity is more than 30% of the average annual input, the success of leaching is less. Washing efficiency is the ratio of the volume of sediment removed to the volume of water used for washing. For complete washing, different ratios of washing efficiency of reservoirs vary from 0.01 to 0.17. Has been released, the following items should be considered in the costs related to a quick wash event:

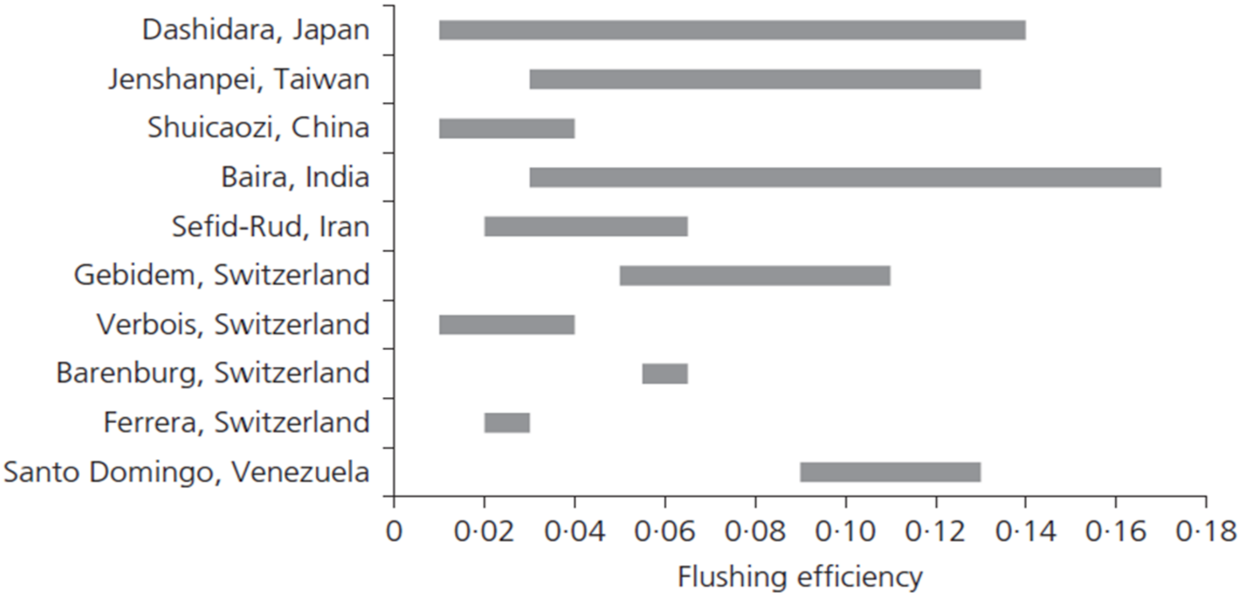
A) preparation costs including planning, notification, preparation work.

b) External control, supervision.

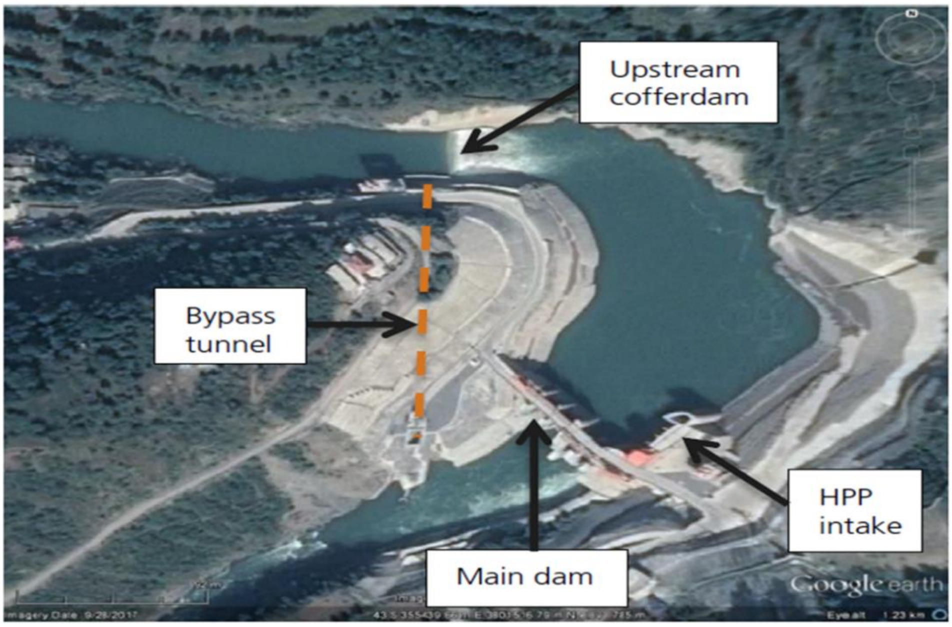
c) Costs after the evaluation process, environmental monitoring, restoration of fisheries, including the loss of other uses, for example, electricity production.

3.2. Dredging time and reservoir geometry:

When there is a flood season, the best time to carry out the washing is at the beginning of the flood season, because it also takes advantage of the low level of the reservoir at the end of the dry season, so the water is not lost when emptying, and many reservoirs are washed together in this way. Are, the flows of the early flood season usually carry the highest amount of annual sediment, so a combined washing and reducing effect is obtained. Flood forecasting and upstream monitoring are essential in rainfall events, and appropriate flow level operating curves are used for harvesting. If there is a season of water demand, discharges outside that season may occur both to prevent further accumulation and to flush whenever high flows occur. When planning timing, downstream environmental effects should also be considered. Commented According to the width of the reservoir, there are two possible limitations for washing and removing sediments from the entire width of the reservoir: a) The bottom width of the reservoir should be narrow and limit the width of the washing channel. b) The upper width of the washing channel is not limited. The desired location for de watering is often selected using three-dimensional spiral flows, whereby sediment-free water near the surface flows toward the outer bend, while near the bed the sediment-rich stream flows toward the inner bend and is deposited. This flow pattern recommends running the washing channel towards the outer bend, thus limiting its ability to erode sediments from the entire width of the reservoir, so the use of the wall to concentrate the washing flow in the center of the channel instead of the outer bend to clean the sediments. It helps on the side of the inner bend. Picture 3 shows the implementation of flushing for the Path rind dam reservoir in Pakistan.



Washing efficiency for different dams



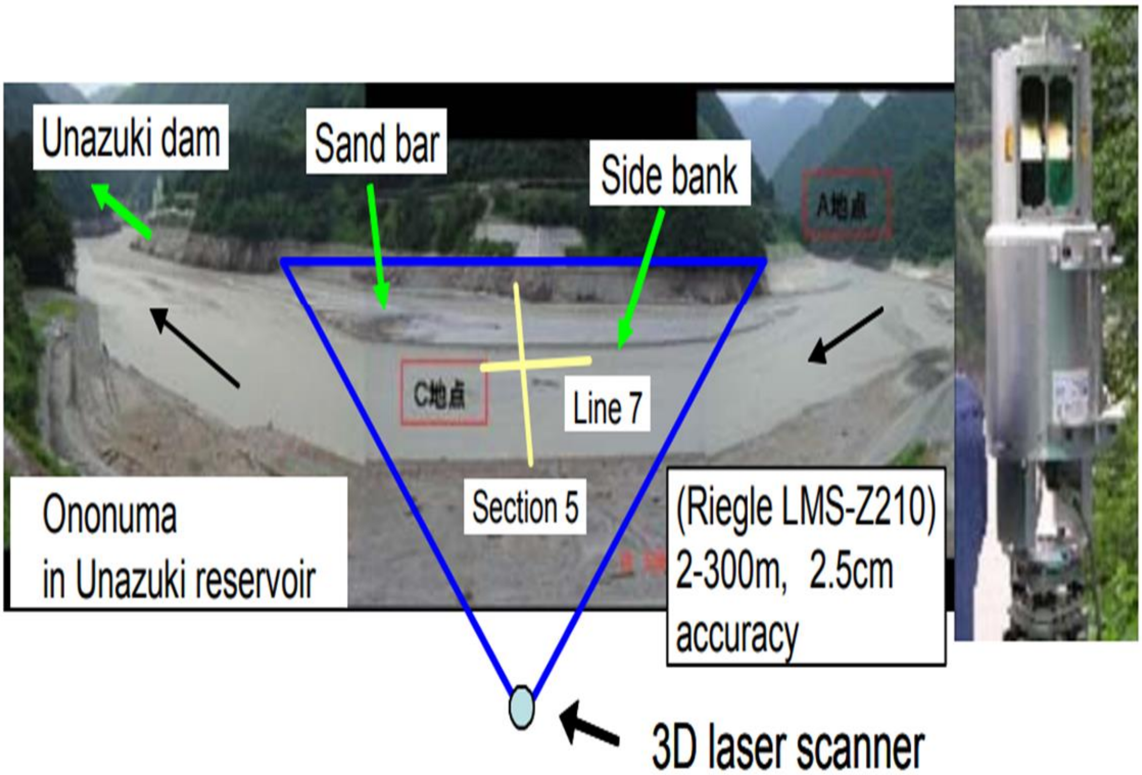
Picture 3

3.3. Sediment discharge valve:
In general, the discharge valve should be able to release water without turning it back, and in semi-arid areas, it should be able to transfer 1 flood in 5 years. Also, this valve should be placed in the main bed of the river entering the dam in order to function properly. The impact of these sluices on the Sandmen Dam in China has increased the output capacity and sediment discharge.

3.4. A few tips for a successful washing operation:
Descaling is effective when the movement of water and sediment occurs in the reservoir. The younger and unconsolidated sediments are the better descaling is done. - The shorter the length of the reservoir, the better the descaling is done. - The straighter the path of the reservoir is in the direction of the main stream, the more appropriate the sedimentation will be. - The finer the size of the sediments and the steeper the slope of the main river, the better the sedimentation is done. Environmental changes related to sedimentation in the downstream rivers have caused changes in the river channel, growth of trees around the river and changes in the river bed materials. Picture 4 shows the longitudinal and lateral erosions created on the river by the Dashidaira dam reservoir in 2003. It shows that it has caused the destruction of the bed and the erosion of the side slope.

Picture 4

Recently, lenses and 3D laser scans have been used to measure the erosion process of reservoirs and water surface profiles near the slopes, so it is possible to use this method to understand sediment transport in a reservoir, to estimate the volume of sediments discharged by operation. Sedimentation and temporal and spatial changes in the reservoir level were used. Picture 5 shows sedimentation in Unazuki reservoir by 3D laser scanner.



Picture 5

4. Modeling sediment removal from the reservoir

4.1. Physical modeling of reservoir descaling:

In many conditions, laboratory studies are used for the optimal design of hydraulic structures. Despite the wide application of laboratory studies, the use of this method has limitations that make its use difficult or uneconomical in many situations. One of the problems of this method is the space limitation for building the physical model. But the most important problem that occurs in the use of physical models is related to the error caused by scaling the original sample. If the sediments in the reservoir and the stream are modeled on the same scale as the dam components, then the dimensions of the sediments used in the physical model should be very small, which in this case will show a completely different behavior from what happened in the original sample. They give. Therefore, sediments with larger dimensions must be used, which causes errors in the results. On the other hand, another solution that exists to solve this problem is to use sediment particles with a lower density than the sediments in the original sample. In this case, according to the studies, if the fluid used is water, the laws of similarity cannot be satisfied. Another problem that exists in the physical modeling of flow with sediment transport is the failure to model the entire grain size curve in the original sample, because in order to model the fine grain spectrum of the grain size curve, it is necessary to use sticky grains that are not logical. For this reason, many researchers believe that the use of a physical model in works related to sediment transport only provides a qualitative estimate of the physics of the problem. Despite all the existing limitations, the use of this modeling method has been proposed as a key solution for years. Was and in addition, the data obtained from this modeling method is always used as a reference for validating the results of numerical models and their calibration. To the extent of the conducted investigations, the application of the laboratory studies conducted in the field of sediment removal of the reservoir of dams includes the following: - It can be used to investigate the depth of the discharge cone in front of the sedimentation valve and the effect of the flow parameters and the discharge valve on it. He also conducted a comprehensive laboratory study on the physical model of the dam reservoir and measured the profile of the bed after sediment washed in the transverse directions of the reservoir and at different distances from the sediment discharge valve. Also, comprehensive laboratory studies have been carried out by the United States Civil Administration to obtain the criteria for the design of sediment removal ducts. Other laboratory studies for the optimal design of descaling facilities have been conducted by Atkinson (1987 and 1986) also at the Welling Ford Hydraulic Research Center.

4.2. Numerical modeling of reservoir descaling

Considering the limitations that were briefly mentioned in the laboratory study method, another prominent option is to prepare a suitable numerical model to investigate the effect of different parameters on the efficiency and functioning of the sediment removal channel. In comparison with laboratory studies, the preparation of a numerical model has the following advantages: - Problems related to scaling the original sample are not mentioned. - It is cheaper compared to the physical model method. - Contrary to the physical modeling method, in this method, the whole spectrum of sediments can be modeled. Considering the advantages of using a numerical model in predicting the performance of the sediment removal channel and discharge valve for optimal design and quantitative evaluation of the system performance, in this review article, a numerical model will be presented that can evaluate the effects of different parameters on the flow field and sediment transfer. And finally, it should be used in the optimal design of sediment removal channels and output hydrography and the range of reservoir water level changes. Such a numerical model should be able to take into account all the influencing features of the flow such as flow turbulence and bed friction or bed shear stress. This model should also properly simulate the irregular geometry of the river bed and reservoir bottom, the geometry of the sediment discharge valve. In general, the presented numerical model should be able to provide appropriate answers to the following two important questions: - How much sediment is removed from the reservoir as a result of descaling? - What is the spatial distribution of sedimentation in the reservoir after sedimentation? In the following, the numerical and laboratory studies conducted in this field are analyzed separately. So far, many researchers have done numerical simulation of sediment removal of dam reservoirs and have presented one, two and three-dimensional models for this purpose, which will be studied separately in the following.

4.2.1. One-dimensional models

Depending on the assumptions used in the numerical modeling, two categories of governing equations have been used for numerical simulation. In the first category, the following assumptions are used to extract the governing equation: A- The descaling of the reservoir takes place under the conditions of uniform free flow from the reservoir and the descaling channel. B - The flow per unit width in the reservoir can be calculated from the following equation:

$$q_s = c_1 T_b^{3/2} \quad (1)$$

In this equation, qs is the flow rate per unit width, C1 is the experimental coefficient and Tb is the shear stress of the bed. Using the above assumptions, the sediment continuity relationship is obtained as follows.

$$\frac{\partial z_b}{\partial t} - a\frac{\partial^2 z_b}{\partial x^2} = 0 \quad (2)$$

In this equation, Zb is the number of the bottom of the reservoir and a is a coefficient that depends on the flow conditions and characteristics of the sediment grains, in this category of models, by numerically solving the governing equation (2), the changes in the level of the bed bottom according to different input currents. It is calculated. They solved the governing equation (2) by using the finite difference method and the Crank-Nicholson discretization method.

The second category of one-dimensional equations that are used to simulate the descaling of reservoirs are the basic equations of unsteady flow or saint-venant equations (including equations of continuity of flow and conservation of one-dimensional momentum) in addition to the equation of continuity of sediment. The most important assumptions considered in deriving these equations are:

A- Hydrostatic pressure distribution

B - uniform distribution of speed in the section

C - extracting the slope of the energy line from the relationship related to uniform flow

The equations governing the flow for this state can be written in the following conservation form:

$$\frac{\partial w}{\partial t} + \frac{\partial F}{\partial x} = D \qquad (3)$$

$$w = \begin{bmatrix} A \\ Q \end{bmatrix} \qquad F = \begin{bmatrix} Q \\ H \end{bmatrix} \qquad D = \begin{bmatrix} 0 \\ G \end{bmatrix} \qquad (4)$$

$$n = uQ + \frac{F_n}{p} \qquad G = gA\left(s_y - s_f\right) \qquad (5)$$

$$Q = \frac{1}{n} A R^{2/3} s_f^{1/2} \qquad (6)$$

$$F_n = \gamma \int_0^h (h - \xi) B(\xi)\, d\xi \qquad (7)$$

$$\frac{\partial A_s}{\partial t} + \beta \frac{\partial Q_s}{\partial x} = 0 \qquad (8)$$

In these equations, x is the distance from the beginning of the tank or channel, t is time, A is the cross-sectional area of the flow, Q is the volume flow, g is the acceleration of gravity, u is the average flow velocity, S0 is the slope of the channel floor or the slope of the tank bed and Sf is the slope of the energy line, which is from The following relationship is obtained (assumption c): where n is the Manning's roughness coefficient, R is the hydraulic radius and Fn is the force caused by the hydro static pressure on the cross-section of the channel, which is calculated from the following equation: where γ is the specific weight of water, h is the depth of flow, ξ is the distance from the bed and B(ξ) is the cross-section width of the channel at the distance ξ from the bed. For one-dimensional numerical simulation, in addition to the above two equations, the following sediment continuity equation is used.

In this equation, as is the volume of removed or deposited sediments per channel width unit, Qs is the volume flow rate of sediments, and β is a constant coefficient. Empirical relations are used to estimate sediment discharge in equation (8). McCormack's method is used to solve the equations (3) and (8), the mentioned numerical method is an elliptic method with two calculation steps of predictor-corrector and has second order accuracy. In this method, in the first step, the value of the unknown variables is estimated, and in the second step, these calculated variables are used to calculate the final value of the unknown variables at the end of the time step Δt. By using the mentioned method in equations (3) and (8), the following relationships are obtained. Estimation algorithm:

$$\tilde{A}_i^{n+1} = A_i^n - \lambda[Q_{i+1}^n - Q_i^n] \qquad (9)$$

$$\tilde{A}_{Si}^{n+1} = A_{Si}^n - \lambda[Q_{Si+1}^n - Q_{5i}^n] \qquad (10)$$

$$\tilde{Q}_i^n + 1 = D_i^n - \lambda[H_{i+1}^n - H_i^n] + \Delta t G_i^n \qquad (11)$$

Correction algorithm:

$$A_i^{n+1} = \frac{1}{2}\left\{A_i^n + \tilde{A}_i^{n+1} - \lambda\left[\tilde{Q}_i^{n+1} - \tilde{Q}_{i-1}^{n+1}\right]\right\} \qquad (12)$$

$$A_{si}^{n+1} = \frac{1}{2}\left\{A_{si}^n + \tilde{A}_{si}^{n+1} - \lambda\left[\widetilde{Qs}_i^{n+1} - \tilde{Q}_{si}^{n+1}\right]\right\} \qquad (13)$$

$$Q_i^{n+1} = \frac{1}{2}\left\{Q_i^n + \tilde{Q}_i^{n+1} - \lambda\left[\tilde{H}_i^{n+1} - \tilde{H}_{i-1}^{n+1} - \tilde{H}_{i-1}^{n+1}\right] + \Delta t \tilde{G}_i^{n+1}\right\} \qquad (14)$$

They used the aforementioned method for one-dimensional numerical simulation of reservoir descaling due to dam failure (which is the same condition of hydraulic regime type descaling by lowering the water level in the reservoir). Also, to check the accuracy of the obtained results, the results can be compared with the results obtained from laboratory studies for the same problem, and finally, it can be concluded that the answers obtained from the one-dimensional numerical model have good accuracy. Also, if the same problem is simulated again using Lax Venderoff's numerical method and compared with the laboratory results, a suitable correlation between the results can be observed. Lax Venderoff's numerical method is an implicit method with two time steps and has second-order accuracy.

The governing equations (3) and (8) that are discretized by the mentioned method are as follows:

$$A_i = \frac{1}{2}\left[(A_{i+1}^n + A_{i-1}^n) - \lambda(Q_{i+1}^n - Q_{i-1}^n)\right] \qquad (15)$$

$$Q_i = \frac{1}{2}\left[(Q_{i+1}^n + A_{i-1}^n) - \lambda(H_{i+1}^n - H_{i-1}^n) + \Delta t(G_{i+1}^n + G_{i-1}^n)\right] \qquad (16)$$

$$A_{si} = \frac{1}{2}\left[(A_{si}^n + A_{si-1}^n) - \lambda(Q_{si+1}^n - Q_{si-1}^n)\right] \qquad (17)$$

Second step:

$$A_i = A_i^n - \lambda(Q_{i+1} - Q_{i-1}) \qquad (18)$$

$$Q_i^{n+1} = Q_i^n - \lambda(H_{i+1} - H_{i-1}) + 2\Delta t G_i \quad (19)$$

$$A_{s_i}^{n+1} = A_{s_i}^n - \lambda(Q_{si+1} - Q_{si-1}) \quad (20)$$

4.2.2. Two-dimensional models

Two-dimensional models in plan and two-dimensional in vertical to simulate the flow field and sediment transport in eroding channels and also to simulate changes in the level of the reservoir bed (as a result of sediment removal) and obtain the mode of changes in the level of the reservoir bed in two dimensions have been used. The governing equation for the two-dimensional flow in the vertical direction is the same as the Navier-Stokes equations, in which changes in the transverse direction are ignored. Also, the equations governing the two-dimensional flow in the plan are the equations averaged in depth, which are used together with the sediment continuity equation. These equations are as follows.

Continuity equation:

$$\frac{\partial h}{\partial t} + \frac{\partial (hu)}{\partial x} + \frac{\partial (hv)}{\partial y} = 0 \quad (21)$$

X-degree momentum equation:

$$\frac{\partial (hu)}{\partial t} + \frac{\partial}{\partial x}\left(hu^2 + \frac{\partial h^2}{2}\right) + \frac{\partial}{\partial y}(huv) = -gh\frac{\partial z_b}{\partial x} - \frac{1}{P}\tau_{bx} + \frac{1}{p}\frac{\partial}{\partial x}(hT_{xx}) + \frac{1}{p}\frac{\partial}{\partial y}\left(hT_{xy}\right) \quad (22)$$

Y-degree momentum equation:

$$\frac{\partial (hv)}{\partial t} + \frac{\partial}{\partial y}\left(hv^2 + \frac{\partial h^2}{2}\right) + \frac{\partial}{\partial x}(huv) = -gh\frac{\partial z_b}{\partial y} - \frac{1}{P}\tau_{bx} + \frac{1}{p}\frac{\partial}{\partial x}\left(hT_{xy}\right) + \frac{1}{p}\frac{\partial}{\partial y}\left(hT_{yy}\right) \quad (23)$$

Sediment continuity equation:

$$\frac{\partial z_b}{\partial t} + \frac{1}{I-\lambda}\left(\frac{\partial q_{xx}}{\partial x} + \frac{\partial q_{sy}}{\partial y}\right) = 0 \quad (24)$$

In these equations, h and Zb represent the depth of the flow and the depth of the bottom channel, respectively, and Ty, Ty, Ty, and Xx are the effective stresses averaged in depth, and qs and qs are the bed sediment load components in the y and x directions, respectively. And λ is the porosity of the bed material. U and v also represent the velocity components averaged in depth in the x and y directions, respectively, and are defined as follows:

$$u = \frac{1}{h}\int_{z_b}^{h+z_b} U\,dz \quad (25)$$

$$v = \frac{1}{h}\int_{z_b}^{h+z_b} v\,dz \quad (26)$$

τby and τbx are the shear stress of the bed in the y and x directions, respectively, which are
defined using the Chezy formula as follows:

$$\tau_{bx} = \frac{g}{c^2}u\sqrt{u^2 + v^2} \quad (27)$$

$$\tau_{by} = \frac{g}{c^2}v\sqrt{u^2 + v^2} \quad (28)$$

In this equation, C is the coefficient of Chezy, the above equations are solved in a non-involving way, in such a way that at each step, the hydrodynamic parameters of the flow, including h, v, u, are obtained by solving the equations number (21) to (23) and then get the value of Zb by solving equation number (24) and continue this process until the convergence of the solutions, to start the next time step, the new Zb can be used as the boundaries of the field.

4.2.3. 3D models

To the extent of the investigations carried out in this review article, the three-dimensional modeling of reservoir sedimentation is only limited to numerical studies on diversion dam reservoirs, which are limited to two cases. The first case is the numerical modeling done by Atkinson. In this three-dimensional model, which was prepared for the numerical simulation of the sedimentation of Kapunga and Ango diversion dam reservoirs, the Reynolds equations and the k-ε turbulence model were used to simulate the flow field in the non-orthogonal curved coordinate system. In this model, the sediment continuity equation along with the suspended sediment transfer equation is used to calculate the bed level. In the mentioned model for simulation, the free surface is considered as a flat plate without friction. The second case is Olsen's numerical study, in which the k-ε turbulence model is used to model the turbulence terms.

DISCUSSION AND CONCLUSION:

The strategy of managing sediments in dam reservoirs or routing sediments according to various parameters should be taken into consideration before building a dam. It should be noted that the washing operation with the help of free hydraulic sedimentation will be much more effective than pressurized sedimentation. Also, it is useful to use 3D laser scanning technology to monitor the sediment erosion process. If the flow is released from the dams, the change in the main flow regimes and the sediment loads caused by the release of water from the reservoirs of the dams can cause changes in the shape and processes of the river, including the flow, water quality, temperature, sedimentation regime, and the slope and bed of the river downstream. Its morphological effects in the downstream should be investigated. Each of the desalination methods should be examined according to the season, climate of the region, considering economic issues and according to the conditions and characteristics of the dam, sometimes the cost of desalination increases to such an extent that the construction of a new dam is much more economical. It comes from reducing sedimentation. The most important aspects that can be examined in each of the methods presented to deal with the problem of sedimentation can include the efficiency of the plan, the costs of the plan, the compatibility of the plan with the building of the dam, the absence of problems downstream of the dam, the adaptability of the plan in different reservoirs and durability. It is used as a plan. It should be noted that the removal of sediments accumulated in the tank is possible with hydraulic washing in certain cases, and a review of the existing literature led to the analysis of the factors that played a role in the successful washing operation, so detailed analysis and planning these factors are essential. It is worth mentioning that narrow and longer tanks are more suitable for washing, and if there is a bend in the tank plan, washing channels (channels or tunnels) can be used to increase the slope (with a shortcut), using methods such as sediment trapping in the catchment basin and drilling upstream can be used to manage large sections of sediment. According to the results of the investigations carried out in this review article, the use of the sediment removal method with the hydraulic regime method is known as one of the cheapest and most effective ways to deal with the problematic phenomenon of sediment accumulation in reservoir dams. In this method, using a jet-like flow with high turbulence, lower sediment discharge valves are used compared to the discharge of sediments into the tank. The efficiency of the mentioned method in emptying the sediments in the tank, in addition to the maneuvering and functioning of the emptying valves, depends on several factors, including: the dimensions of the emptying valves, the appropriateness of the washing time, the number and location of the lower emptying valves, the hydrography of the exit flow from Discharger, the range of tank water level changes and the amount of disturbance caused by the flow field in the place of accumulation of sediments are highly dependent. According to the studies carried out, in order to obtain suitable and acceptable results from descaling of the tank, it is necessary to perform numerical studies to predict the maneuvering and optimal performance of various facilities related to the descaling process, as well as the best output hydrography and the range of changes in the water level of the tank. Should be done and using the results of these simulations to optimize the functioning of various components to empty the sediments as much as possible. In this regard, in this article, a review of different numerical models used in the simulation of the descaling process has been briefly presented. Due to the large volume of reservoirs of large dams, the three-dimensional numerical modeling of their sediment removal is very expensive and requires extremely high-speed processors. Therefore, one-dimensional and two-dimensional models are often used to model the mentioned process in the reservoirs of large dams.

REFERENCES:

1. Petkovsek, G., Kitamura, Y. and Roca, M., 2020. Sediment Flushing From Reservoirs, Dams and Reservoirs, 30 (1), 12-22.
2. Reisenbuchler, M., Duc Bui, M., Skublics, D. and Rustchmann, P., 2020. Sediment Management at Run-of-River Reservoirs Using Numerical Modelling , Water, 12 (1), 249.
3. Ren, S., Zhang, B., Wang, W., Yuan, Y. and Guo, C., 2021. Sedimentation and its response to management strategies of the Three Gorges Reservoir, Yangtze River, China, Catena, 199, 105096.
4. Tan, G., Chen, P., Deng, J., Xu, Q., Tang, R. and Feng, Z., September 2019. Review and improvement of conventional models for reservoir sediment trapping efficiency, Heliyon, 5 (9), e02458.
5. Choukri, F., Raclot, D., Naimi, M., Chikhaoui, M., Nunes, J., Huard, F., Herivaux, C., Sabir, M., and Pepin, Y., 2020. Distinct and combined impacts of climate and land use scenarios on water availability and sediment loads for a water supply reservoir in northern Morocco, International Soil and Water Conservation Research, 8(2), 141-153.
6. Althaus JJ and De Cesare G ., 2006 Sustainable Sediment Management in Alpine Reservoirs Considering Ecological and Economical Aspects. Volume 3: Reservoir Sedimentation.
7. Grimardias D, Guillard J and Cattaneo F., 2017 Drawdown flushing of a hydroelectric reservoir on the Rhone River: impacts on the fish community and implications for the sediment management. Journal of Environmental Management 197: 239–249.
8. Gomi T, Kobayashi S, Negishi JN and Imaizumi F., 2010 Short-term responses of macroinvertebrate drift following experimental sediment flushing in a Japanese headwater channel. Landscape Ecological Engineering 6: 257–270.

9. Espa P, Brignoli ML, Crosa G, Gentili G and Quadroni S., 2016 Controlled sediment flushing at the Cancano Reservoir (Italian Alps): management of the operation and downstream environmental impact. Journal of Environmental Management 182: 1–12.
10. Kondolf GM, Gao Y, Annandale GW et al., 2014 Sustainable sediment management in reservoirs and regulated rivers: experiences from five continents. Earth's Future 2(5), 256–280.
11. Atkinson, E., 1995 ”A Numerical model for predicting sediment exclusion at intakes.” Report OD 130, HR Wallingford, Oxfordshire, UK.
12.Sumi, T., and Kantush, S.A., 2010 “Integrated Management of Reservoir Sediment Routing by Flushing, Replenishing, and Bypassing Sediments in Japanese River Basins” , Disaster Prevention Research Institute, Kyoto University Goka-sho, Uji-shi, 611-0011.
13. Olsen, N. R. B.1999 ”Three-dimensional numerical modelling of flushing processes in water reservoir”, IAHR Journal of Hydraulic Research, Vol. 38, No.1.
14. Shen, H. W., and Lai, L. S., 1996 “Sustain reservoir useful life by flushing sediment”, International Journal of sediment Research, IRTCES, Vol. 11, No. 3.
15. Bellos, C., and Hrissanthou. V., 1995 “Mathematical simulation of sediment release from a reservoir” ٢nd. Int. conference on Advances in Hydro-Science and Engineering, Vol. 11.