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A New Sedimentation Decreasing Phenomenon A Case Study: Dez Irrigation Network

S. Torfi and H. Makenalizadeh

Department of Mechanical Engineering,
Susangerd Branch, Islamic Azad University, Susangerd, Iran

Abstract: Sedimentation phenomenon in rivers, irrigation and drainage systems is a problem that has become a main economic challenge along with problem related to utilization and maintain ace due to its special condition of silting. Resent study deals with deferent aspects of sedimentation and suggests some effective solutions. Method of the research includes selecting three channels in Dez network and determining 17 study stations. After that sampling and measurement and essential experiments were performed monthly from November 2007 to February 2008. Obtained results showed that sediment deposition causes 64 percent increase in roughness coefficient that results to 26 percent decrease in conveying capacity. The results also showed that lack of intake in flood flows prevents sediment entering to the network. In such conditions, rate of the flow could be reached to non-silting velocity and the height of water (level) in channels could be decreased. Obtained results also showed maximum conformity with Girtin method and after that with limiting concentration theory in determining velocity of non-silting condition for Dez network.

Key words: Sedimentation phenomenon · Conveying capacity · Minimum non-silting velocity

INTRODUCTION

A Nowadays, soil erosion and sedimentation process followed it, are two challenging issues in management of resource such as water, soil and watershed, that have undesirable effects on river basin generally and behind dams and irrigation structure in special. Sever erosion in watershed basin of Iran cause accumulation of sediment in reservoir dam, water transport and distribution structures and wide agricultural and lost its profitability. Problems that results directly from sediment deposition in irrigation system include decrease of hydraulic capacity (transportation) of canals, gradual erosion and destruction of structure walls due to transport and accumulate of coarse grained materials, erosion and corrosion of parts and accessories of pumping stations due to high amount of suspended sediment in pumping system and high cost of channel dredging. Therefore the study deals with different aspects of sedimentation process and investigate solutions for decreasing its effects.

Review of Literature: Many researches have been conducted in this field and different theories presented, but all these methods are based on water flow velocity. These methods can be classified to three groups include:

A: Methods based on minimum non-silting Velocity based on these methods. If velocity of the water reached to the point where all potential suspended sediment that have the probability of entrance to the channel based on designation, doesn't deposit, it is called minimum non-silting velocity. In relations presented in the study, in addition to hydraulic characteristics of the flow, factors such as suspended material concentration, particle diameter and roughness coefficient of channel bed are considered [3].

Regime Theory: Regime theory was presented by lindy and Kennedy for the first time according to empirical experiments.

Kennedy and lindy concluded that there is a velocity related to depth that can prepare regime condition for channels. Based on the theory, regime condition is related

Corresponding Author: Sadegh Torfi, Department of Mechanical Engineering, Susangerd Branch, Islamic Azad University, Susangerd, Iran.

to characteristics and dimensions of channel in which there aren't any erosion and sedimentation in walls or bottom. Finally, the researchers presented a relationship between depth and velocity of water flow in channels that showed regime conditions in water transport and distribution structures [4].

Limiting Concentration Method in Open Channels: Based on this theory, each channel has a limiting concentration that above it, some part of suspended sediment in the flow will deposited.

MATERIAL AND METHODS

Studied Area: Dez irrigation and drainage network is the largest modern system in middle east that was fed by west and east channels with capacity of 154 and 44 m^3/s respectively and Dez diversion weir and a channel in stabile with capacity of 16 m^3/s provides water needed by totally 90,000 hectares of sub network lands by a pumping station. All sampling and measurement are performed by these stations [5].

Methods: In this study, 17 stations were selected among some other areas considering special conditions of the environment.

Considering that maximum sedimentation rate accuresin flood flows and they often occur in some special seasons, then it is necessary that sampling is performed during river flooding. The best area that can be used for sampling are these in which water turbulence is severe and almost uniform. Desired areas were selected in the manner that included both sedimentation and non-sedimentation area to investigate the situation comprehensively. In order to investigate these methods, knowing about geometric characteristics of channels profile is necessary. Parameters such as roughness coefficient, bed slope, depth of the flow, cross section, wet area, side slope and hydraulic characteristic such as average velocity of the flow, friction coefficient and energy line slope were necessary.

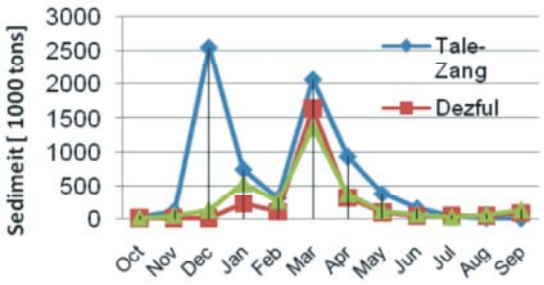

Fig. 1: Comparison of sediment rate in different stations.

RESULTS AND DISCUSSION

Main Reasons of Sedimentation in Dez Irrigation Network: Dez River in satiations located before and after the dam. Table 1 shows annual statistics related to Dez river sediment rate in Tele-zang, Dezful and Bam-Dejh.

As it can be observed from Table 1, total amount of sediment in Tele-zang station (before the dam) is estimated 7380,000 tons and in Dezful and Bam-Dejh stations are 2643,000 and 3217,000 tons respectively. These values show that more than 55% of total sediment passing from Tele-zang station, before dam, is deposited in its reservoir. These results show serious challenges of sedimentation process and soil erosion in Dez dam watershed basin. It can be inferred from these value that, watershed management is poor and also there are problems in utilizing and stability of reservoir dam structures and other sub-network structures.

This is the some alarm existed related to sedimentation problems resulted from upstream soil erosion and their effects on intake of channel mouth and morphologic changes of rivers.

Figure (1) shows that more than 95% rate of sediment pass from the rivers during November to April that was the time of flooding of Dez River.

It can be inferred from the above diagram that in both consecutive period, during sever and continuous precipitation of winter, farming capacity of agricultural lands are completely saturated and water runoff flow to the rivers due to poor plant cover of mountainous area.

Table 1: Annual statistic of Dez river sediment rate in different stations.

	Amount of sediment 1000 tons/day				
Total amount of water m^3	Average	Minimum	Maximum	Total annual sediment (1000tons)	Station
44.7347	21.20	0.95	1100	7380	Tele-zang
82.6753	24.7	0.177	220	2642.89	Dezful
42.6285	82.8	0.439	126	3217.05	Bam-Dejh

Table 2: Discharge decrease (%) caused by sediment deposited in channels

Discharge decrease (%)	Secondary discharge (m/s)	Roughness coefficient	Wet area (m)	Secondary cross section (m^2)	Primary discharge (m^3/s)	Roughness coefficient	Wet area (m)	Primary cross section (m^2)	Channel name
21.25	6.3	0.022	7.8	8.25	8	0.014	9.6	10.5	E_1
26	2.3	0.023	4.7	2.25	3.1	0.014	5.5	3.5	E_1R_1
18.6	4.8	0.019	7.5	6	5.9	0.014	8.83	7.8	E_4

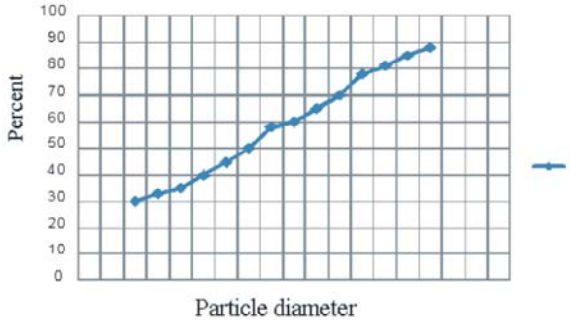

Fig. 2: Aggregation of suspended sediment partakes

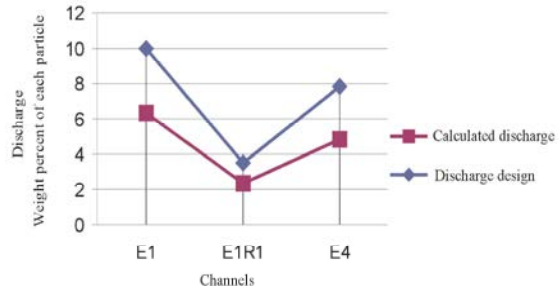

Fig. 3: Rate of discharge decrease of channels caused by sediment deposition

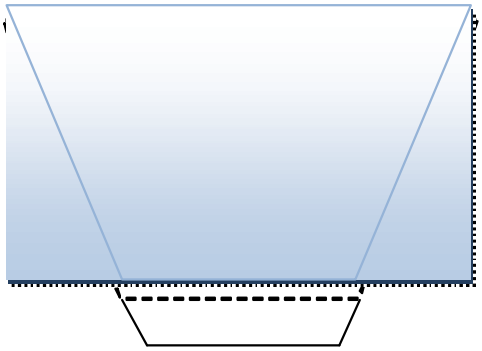

Fig. 4: Height increase of channels

At the beginning of spring sever flows resulted from melting snow and glaciers, this process is repeated and it also due to poor plant cover in basin area and lack of watershed management that sever flood flow and curvy great amount of coarse-grained sediment and store them in rivers and then behind of dam reservoir, that has undesirable effects on utilizing and maintaining structure either environmentally or physical stability aspects.

Results of Aggregation Experiment of Suspended Sediment and Deposited Material in Channels Bed: Suspended materials existed in water of Dez river constitute very fine particles. The average diameter of the particles is 0.007 mm. diameter of silt and clay particles that constitute 100% of suspended materials is varied between 0.06 to 0.003.

Also, in sampling from bed material in flood season (February), silt particles with diameter 0.06 mm, 79.25 percent and other particles with 0.250 and 0.125 mm diameters were observed. Sedimentations process in such conditions not only cause significant changes in rivers path that influence on hydraulic behavior and hydraulic slope of some sensitive points like behind diversion dams and in the vicinity of basins, but also has undesirable effects on channels intake process.

Additionally, as researches show, sedimentation move hydraulic slope toward one side of river and basin by gradually creating sedimentary is land and face related structure with serious threat and utilizing problems [6].

Investigating the Effect of Sediment on Decreasing Conveying Capacity of Water in Channels: In order to investigate the effect of sediments on decreasing channels capacity, hydraulic characteristics of channels such as discharge rate, wet area and roughness coefficient calculated once with regard to utilization time characteristics and other time regarding to present study time (with sediment) and then decrease of discharge rate was determined by comparing them.

Considering obtained results in Table 2, sediment deposition in studied period of time, causes 26% decrease in conveying capacity of the flow. Figure 3 shows discharge changes resulted from sedimentation.

Investigating Studied Channels Regarding Different Methods of Sedimentation: In investigating theories related to determining non silting velocity, if calculation velocities is more than measured velocity, that velocity is silting otherwise it is non-silting Table 3 shows deposited sediment volume in every section channel and the height of established sediment and Figure 4 shows height changes of channel bottom E_1 caused by sedimentation. Results of the examination were shown in Table 4.

Table 3: Condition of different profiles of studied channels regarding sedimentation (February 2008)

Profile condition	Dredged sediment volume (m^3)	Height increase of channals bottom (m)	Station number	Channal name
-	-	-	1	E_1
silting	3163.5	0.35	2	
silting	508.2	0.35	3	
silting	1092.15	0.35	4	
silting	696.9	0.35	5	
silting	275.58	0.35	6	
silting	328.5	0.25	1	E_1R_1
silting	632.5	0.30	2	
silting	183.24	0.25	3	
silting	420.0	0.35	4	
silting	45.9	0.25	5	
silting	210.0	0.25	1	E_4
silting	847.0	0.30	2	
silting	3454.5	0.30	3	

Table 4: Evaluation of calculated velocity by different theories

	Non-silting velocity theory				Regem theory		
Limiting concentration theory	Pavlov ski	Zamarin	Girshin	Levey	USBR	Lacy	kennedy
17	31	38	14	32	45	44	19

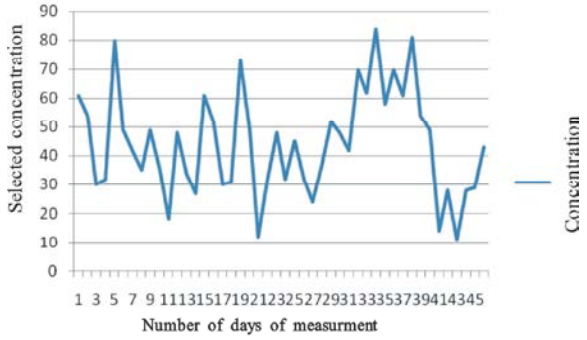

Fig. 5: Measured concentration curve during study period.

Therefore we can conclude from general investigating above mentioned methods that Girshin method (minimum non-silting velocity theory) is the most appropriate method for investigating non-silting condition in channels of Dez irrigation scheme with minimum error rate.

Investigating Lack of Channels Intake and its Effect on Decreasing Sediment: In flood condition that farmer's water requirements reaches to its minimum amount of it, water flow entrance to channels is performed with minimum amount of discharge the minimum flow has high amount of sediment that is deposited simply after entering to the channels. Figure 5 is depicted using measured concentration.

From Figure 5, we can conclude that approximately 25% of network sediment related to 5 special days. (Flood flow) considering obtained results, we can provide some solution for decreasing undesirable effects of sedimentation.

Then, as possible during precipitation and flood condition water flow entered to the river with high concentration that is an important factor of conveying sediment to the network should be prevented. Before beginning precipitation, protective streams of channels (VDICH) should be scoured by special instruments to [revent rain water entering to the channels automation project of water operations in Dez irrigation network can improve utilizing from water resource.

In order to decrease Manning roughness coefficient and providing a systematic maintain ace program such as channels dredging is essential more than ever.

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