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Sedimentary and textural parameters continuity and mineralogical characteristics of the Jajrood river, Iran

Parámetros sedimentarios y texturales de continuidad y características mineralógicas del río Jajrood, Irán

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ABSTRACT

In this research, we try to study the sedimentary characteristics and the trend of textural changes in the sediments of the Jajrood River from upstream to downstream at the point of junction to Latiyan dam. Based on the textural changes of sediments along the path from the upstream in the Garmabdar area to the downstream to the Latiyan Dam, the Jajrood River is divided into four A, B, C and D basins. Twenty sediment samples were collected and all sieved by dry and wet method also the specimens were morphoscopically studied. Data from field and laboratory phases were combined and interpreted using reliable scientific sources and finally a detailed summary was obtained regarding sedimentology of the study area. Mineralogically, the sediment type of the river is a clastic carbonate sedimentary type with fragments ranging from 30 to 58 percent and rock fragments between 25 to 50 percent abundance. Other minerals, such as feldspar minerals, account for about 1 to 4 percent, quartz 5 to 10 percent, and opauqe minerals from 1 to 5 percent. Examination of the average particle size in the A to D basins shows that decreasing trend of sediment size from the A to C basin occurs and reverses in the D basin. In the first three basins, the sorting grade of the river sediments is very bad and in the last basin it has become extremely bad. The amount of kurtosis of the particle distribution curve from upstream to downstream of the river is generally increasing trend. Textural changes along the river do not follow natural conditions due to the influence of various natural factors such as the entry of distributary into the main River, and phenomena such as landslide and rock collapses and debris flows, especially during floods along the riverbank.

Key words: Jajrood river, Latiyan dam, Sediment, Cumulative curve.

RESUMEN

En esta investigación, tratamos de estudiar las características sedimentarias y la tendencia de los cambios de textura en los sedimentos del río Jajrood desde aguas arriba hacia aguas abajo en el punto de unión con la presa de Latiyan. Basado en los cambios de textura de los sedimentos a lo largo del camino desde el río arriba en el área de Garmabdar hasta la presa de Latiyan, el río Jajrood se divide en cuatro cuencas A, B, C y D. Se recogieron veinte muestras de sedimentos y todas se tamizaron por método seco y húmedo, y las muestras se estudiaron morfoscópicamente. Los datos de las fases de campo y laboratorio se combinaron e interpretaron utilizando fuentes científicas confiables y finalmente se obtuvo un resumen detallado sobre la sedimentología del área de estudio. Desde el punto de vista mineralógico, el tipo de sedimento del río es un tipo sedimentario de carbonato clástico con fragmentos que van del 30 al 58 por ciento y fragmentos de roca entre el 25 y el 50 por ciento de abundancia. Otros minerales, como los minerales de feldespato, representan alrededor del 1 al 4 por ciento, los cuarzos del 5 al 10 por ciento y los minerales opacos del 1 al 5 por ciento. El examen del tamaño promedio de partícula en las cuencas A a D muestra que se produce una tendencia decreciente del tamaño del sedimento de la cuenca A a C y se invierte en la cuenca D. En las primeras tres cuencas, el grado de clasificación de los sedimentos del río es muy malo y en la última cuenca se ha vuelto extremadamente malo. La cantidad de curtosis de la curva de distribución de partículas de río arriba a río abajo es generalmente una tendencia creciente. Los cambios de textura a lo largo del río no siguen las condiciones naturales debido a la influencia de varios factores naturales, como la entrada de distribución en el río principal, y fenómenos como derrumbes y derrumbes de rocas y flujos de escombros, especialmente durante las inundaciones a lo largo de la orilla del río.

Palabras clave: Río Jajrood, presa de Latiyan, sedimento, curva acumulativa.

1. INTRODUCTION

Miall (2000) believed that by combining sedimentary data it can reconstruct the sedimentary environment of a river. Miall (1985) presented a comprehensive approach on the subject of determining and classifying sedimentary facies of rivers; he also completed and modified this method in 2000 and 2006. According to Miall (2006), each facies represents a specific sedimentary event. Of course, one can also refer to the studies of Walker and James (1992), Mc Lane (1995) on advanced sedimentary models, as well as Reading (1996), Prothero and Schwab (1996).

Some studies have also been carried out regarding the classification and analysis of textural parameters and sedimentary environment of rivers in Iran. For example, research conducted by Behzadi Nasab (2008), Moghimi (2011), Ahmadi (2002), Khodami et.al (2005), Khanehbad (2002), and Nazari (2005), some of which investigate the textural parameters of sediments in the river environment and the determination of structural elements and its sedimentary model. Many studies have been done on sedimentology and textural parameters in the sedimentary environment of rivers and the causes of its changes; some of these studies are: study of particle size and composition changes in the Mayan River located in southwestern Mashhad (Mousavi Harami et.al., 2001), investigation of sediment downstream-coarsening in the Kashafrood River (2002), relationship between sedimentary continuity and textural parameters in Radkan River (Mousavi Harami et.al., 2003), investigation of textural changes with evidence of downstream-fining in the Dehbar River (Mousavi Harami et.al., 2002), sedimentological studies and downstream-fining rate of Golestan Dam drainage basin, southwest of Mashhad (Mousavi Harami et.al., 2003), and investigation of the of the river bed sediment deposition particle dispersion in the Baqmaj River (Mousavi Harami et.al., 2008). These studies analyzed the textural parameters of the samples along the river and the factors affecting the fining or coarsening process. They found that in each watershed, depending on its conditions, factors such as bed slope changes, stream power, connection of sub-branches to the main channel, and human factors could play a major role in the process.

With extensive studies on texture, sedimentary structures, fossils, and lithology of sedimentary rocks at the outcrop scale, well wall, or in a small part of the sedimentary basin, Miall (1977, 1985, 2000, and 2006) introduced the term Lithofacies. Miall believes that the lithofacies of a section of sediment represents its own sedimentary environment. These facies can be classified into sets and have indexes of particular sedimentary environment characteristics. The shapes of the facies sets are the basis of the determination of the lithofacies models, which are usually cyclic. In 1977, he introduced the rock facies classification which is used today in sedimentology of the river environment and described their role in determining the type of river channel. In 1985, for the purpose of better analysis of river deposits and sedimentary pattern determination, Miall divided these deposits into local sub-sets each of which could be one or a combination of eight structural elements observed based on the type of facies formed in the river channel wall. These structural elements were modified again by Miall in 1977, 1996, and 2006. It should be noted that caution is needed on the concept of these structural elements and their application in field studies (Bridge 2003, Bridge and best, 1988 and 1997; Miall, 1996).
Studying the sedimentology of the Polrood River, Shaban Gorji (1999) stated that the sediments of the river have a bad sorting which gets better toward downstream. Sedimentary changes and fining toward downstream do not have a particular order due to the entry of sub-branches to the main channel. In addition, the skewness of the sediments is mainly positive, and most samples show skewness toward the fine particles.
Examining the factors affecting the morphology of the Ghezel Ozan River, Peyrowan et al. (2011) noted that the coarse particle entry from the sub-distributaries into the main path of the Ghezel Ozan River at the site of active alluvial fans stopped the fining process of sedimentary particles from upstream to downstream of the river. The entry of large volume of coarse grains from these distributaries at the time of the floods has caused the river channel displacement and even morphological change from the meandering state to the furcation state.
Taheri (2009) studied sedimentology and morphology of a part of the Atrak River in northeast Bojnourd. Sedimentological analysis and trend of changes in texture parameters in an area of the river with a length of 63.18 km showed that the river bed material in this interval is mostly of sandy material, and the river has fine grains in this area. Another point is that the texture changes along this river is complex and does not indicate a particular trend; different natural and abnormal factors can be effective in this phenomenon. The most important factors were introduced to be entry of sub-branches and change of river bed slope.
Studying the granulometry curves and diagrams of the Mighan River, Shams and Mousavi (2006) have pointed out that there are various reasons such as the connection of sub-canals along the route, the change of land material, topographic changes of adjacent lands, bed slope changes, mixing river sedimentation with old terraces as well as water use in agriculture that can cause inconsistency and lack of significant changes in sediment granulometry along the river path. They can also prevent the statistical parameters changes trend resulted from sediments granulometry following a certain pattern. Studying the sediments of Sefidrood River, Kamranpouri (2002) has also pointed out the effect of sub-branches and dams in the river path on the particle size change process.
In this research, we try to study the sedimentary characteristics and the process of textural changes in sediments of the Jajrood River from upstream to downstream at the point of arrival at the Latiyan dam.

2. METHODOLOGY

In sedimentological studies, 20 sediment samples have been collected along the Jajrood River at intervals of 1 to 2 km from the riverbed and also downstream of the junction of tributaries, which covers the path from Garmabdar to the Latiyan Dam (Fig. 1). After preparation, the samples were sieved by wet shaker sieve method, and then their texture parameters (Tucker, 2001; Simon & Kenneth, 2001) were measured. Meanwhile, the amount of suspended load (silt and clay) of the river was measured by a particle seizer device.

Figure 1. Sample points map of Jajrood River in four basins A to D

According to the American Society of Civil Engineers method, sampling by hand shovel for coarse and fine sediment performed in 20 cm and 5 cm of depth respectively. The amount of sediment that needs to be removed depends on the size of the sediment. The amount of samples become more with increasing particle size because it should be representative of all parts of the sediment (Feiznia, 2008).

Totally, 20 samples with 5 kg weight per sample of river bed were collected and used for dry and wet granulometry. The samples were morphoscopically studied with binocular. With attention to the importance of morphometric studies to identify erosion and energy of the environment and distance from the origin, the samples of the µ125 sieve particles were studied by binocular microscope for morphology parameters, mineralogy and abundance of sediment components. For better and more precise examination of sorting or abundance of fine and coarse grains of samples, statistical parameters as mean, skewness, sorting, and Kurtosis were used by graphic curve.

Mean: The average particle size in the sediment obtained by the following formula:

$$Mz = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$$

Uniformity or Sorting is the proximity of the particle size of the sediment constituents to be measured by Graphic Standard Deviation, Inclusive Graphic Skewness, and Kurtosis.

The following equation is used to measure the parameter of Inclusive Graphic standard deviation:

$$\delta i = \frac{\varphi_{84} - \varphi_{16}}{4} + \frac{\varphi_{95} - \varphi_{5}}{6/6}$$

Folk (1974) presented the following classification for particle sorting by standard deviation (Table 1).

Table 1. Comparison of particle sorting

Type of skewness	**The amount of sorting according to Phi**
Very good	<0.35
Good	0.35-0.5

Moderately good	0.5-0.71
Moderate	0.71-1
Bad	1-2
Very bad	2-4
Extremely bad	>4

Sorting of all samples was compared with Folk scale. The inclusive graphic skewness parameter was introduced by Folk (1974), and the following formula is used to calculate it:

$$SK_i = \frac{\varphi_{16} + \varphi_{84} - 2\varphi_{50}}{2(\varphi_{84} - \varphi_{16})} + \frac{\varphi_5 + \varphi_{95} - 2\varphi_{50}}{2(\varphi_{95} - \varphi_5)}$$

The calculated value of this parameter is an integer that should not be followed by a Phi symbol; it is shown by positive or negative symbol unless the curve is symmetric, where the value is zero. Folk presented a scale as the following for classifying the grains skewness (Table 2).

Table 2. Comparison of particles skewness

Type of skewness	**Amount of skewness according to Phi**
Very fine skewness	+1 – (+0.3)
Fine skewness	+0.3 – (+0.1)
Moderate skewness	+0.1 – (-0.1)
Coarse skewness	- 0.1 - (-0.3)
Very coarse skewness	- 0.3 – (-1)

The Kurtosis of the particle distribution is calculated by the following formula:

$$KG = \frac{(\varphi_{95} - \varphi_5)}{2/44(\varphi_{75} - \varphi_{25})}$$

If the middle part of the curve has a better sorting, it is called a leptokurtic curve and if the tailed part has a better sorting than the middle of the curve, the curve is wider and it is called platykurtic. Folk provides the following scale for classifying curves kurtosis (Table 3).

Table 3. Comparison of particles kurtosis

Type of kurtosis	**Amount of kurtosis according to Phi**
Very wide	< 0.67
Wide	0.67 – 0.9
Moderate	0.9 – 1.11
Stretched	1.11 – 1.5
Very stretched	1.5 – 3
Extremely stretched	> 3

3. RESEARCH FINDINGS

In this study, textural changes of sediments of the Jajrood River from upstream to downstream were investigated. To interpret the sedimentology of the river, based on the texture variations along the river, the Jajrood River was divided into four basins. The results of each basin are as follows.

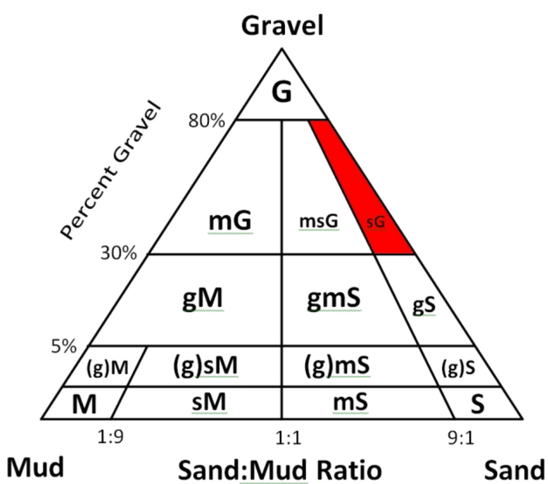
Basin A of the Jajrood River

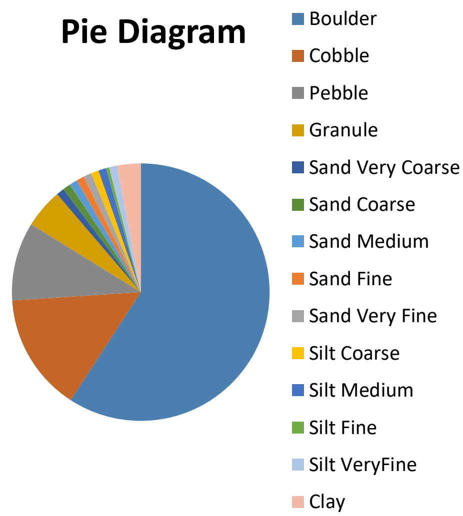
Results of granulometry

This part of the river has high current energy due to the steep slope. According to field observations in this area, sediment particles vary in size from coarse grained sand to cobble and boulder with very bad sorting and particles have low roundness. Based on the Folk diagram (1974) is a gravel sandy sedimentary type (Fig. 2).

Gravel Cent: 61.432 Sand Cent: 34.714 Mud Cent 3.855

Weight of >63: 211.520 Weight of <63: 8.480 Total Weight: 220.000





Sediment Type: Sandy gravel

Fig.2 - Sediment type of basin A in Folk and circular diagram

The graph3 shows the percent abundance of sediment components on a phi scale. This graph can be used to determine the abundance of sand and silt particles in coarse and fine subclass.

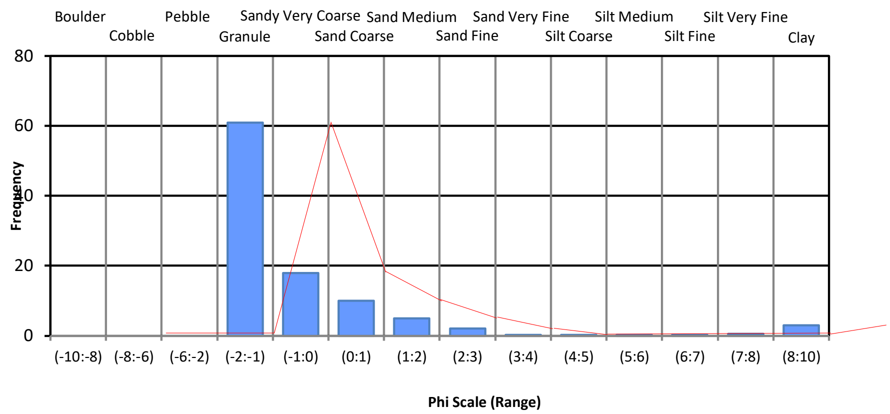


Figure 3. Histogram of grain analysis with Phi scale and full particle size details

The cumulative curves are obtained by summing the weight percent of the particles measured in a class by the percentage of particle size in the previous class. In this section a cumulative curve with a millimeter scale is drawn (Fig. 4).

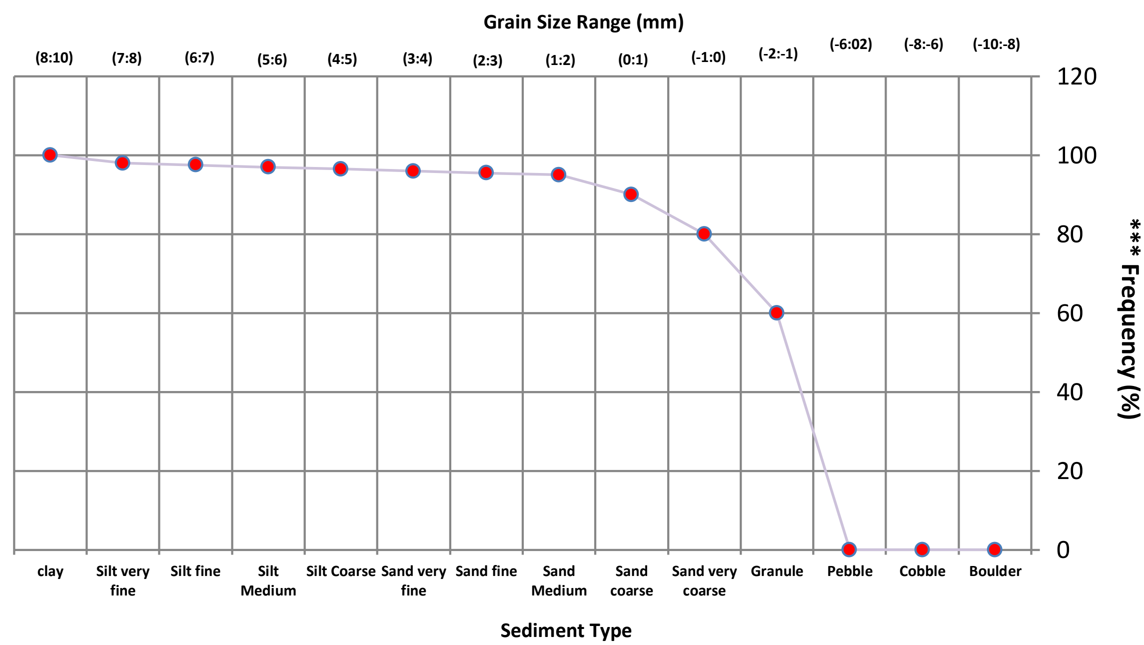


Figure 4. Cumulative curve with millimeter scale

Statistical Parameters

After determination of particle size and drawing curves, mean, sorting, skewness and frequency of coarse- and fine-grained particles are compared (Table 4).

Table 4: Statistical parameters of sediments of basin A of the Jajrood River

Parameter	Value	Description
Mean particle size by Phi (MZ)	-3.381	Coarse-grained particles
Inclusive Graphic. Std. Dev	2.349	Very bad sorting
Inclusive Graphic Skewness	0.395	Extreme skewness towards fine particles (high frequency of fine particles)
Kurtosis	0.748	Platykurtic (curve sequence is better sorting than middle of the curve)

Sediment sorting is weak and very weak and varies within the range (1.96 phi) to (2.34phi). The skewness of the sediments to downstream of the river has different variations. The sediment samples studied in the study area have a positive skewness and variability range (0.395 to 0.85). Positive skewness is normal in river environments and indicates an insufficient opportunity for water flushing of fine particles.

Mineralogy and morphology of sedimentary grains

In basin A on upper part of the river, the shape of the grains is mostly blade and rod and roundness amount of low to angular and very angular (Figure 5).

Table 5 - Distribution of components of fine-grained sediments under binocular microscope

Others%	Rubble%	opaque%	Quartz%	Feldspar%	Muscovite%	Biotite%	Destructive Lime	Skeletal crumbs%	Sample no.
2	30	1	5	1	-	3	58	-	**A-1**
-	34	1	7	1	-	4	53	-	**A-2**

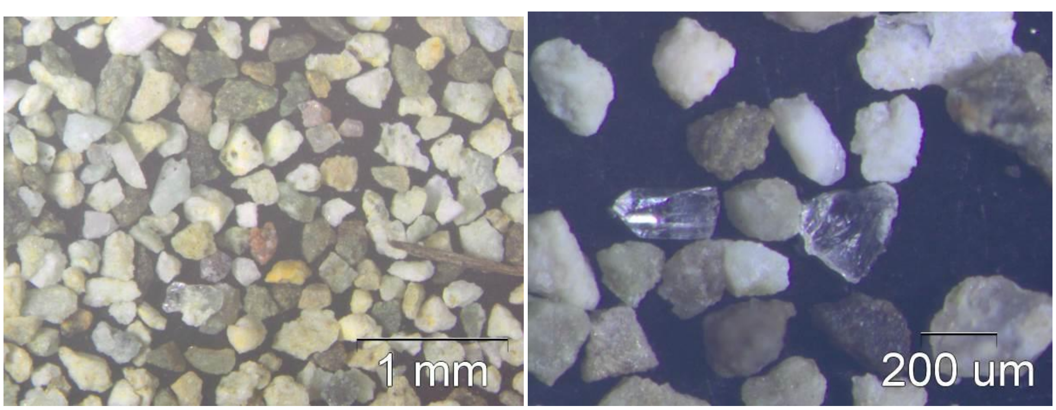


Figure 5- Microscopic images of the particles passed of µ125 sieve related to sample A-1

Comparing the results of field observations and morphoscopic studies, it can be concluded that this part of the river is a little distant from the source and the energy in this environment is high because the particles are angular with low roundness.

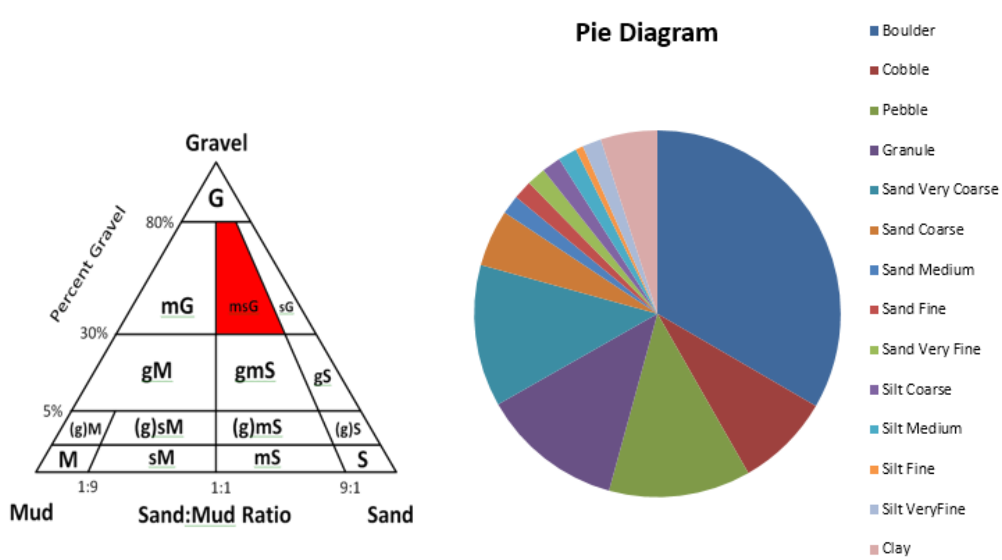
Basin B of the Jajrood River

Results of granulometry

In this part of the river, according to field observations, the sediments of the channel bed are of varying sizes from coarse grained sand to cobble with very bad sorting; and the particles have angular to semi-rounded moderate roundness. In this part, the river has a normal course, and due to the high slope, only in some areas, there are longitudinal dams. In this area, the steep slope of the Jajrood River channel prevents the formation of transverse dams in the river channel.

Gravel Cent: 34.642 Sand Cent: 52.829 Mud Cent: 12.529
Weight of >63: 313.200 Weight of <63: 44.860
Total Weight: 358.060

Pie Diagram Folk Diagram:



Muddy sandy gravel Sediment Type:

Fig.6 - Sediment type of basin B in Folk and circular diagram

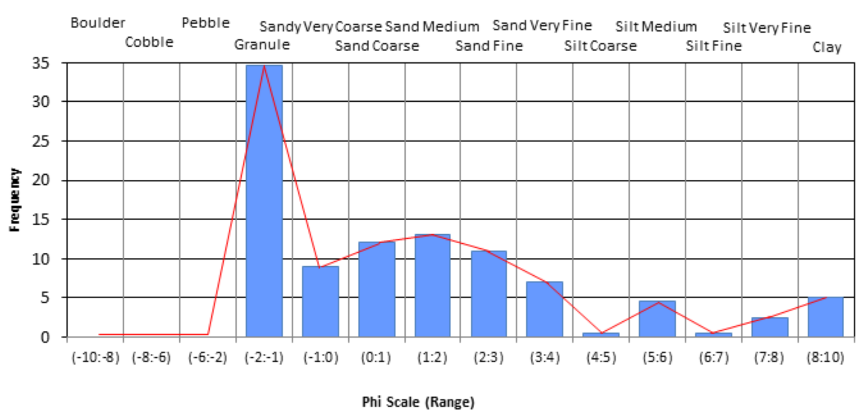


Figure 7. Histogram of grain analysis with Phi scale and details of the particles size

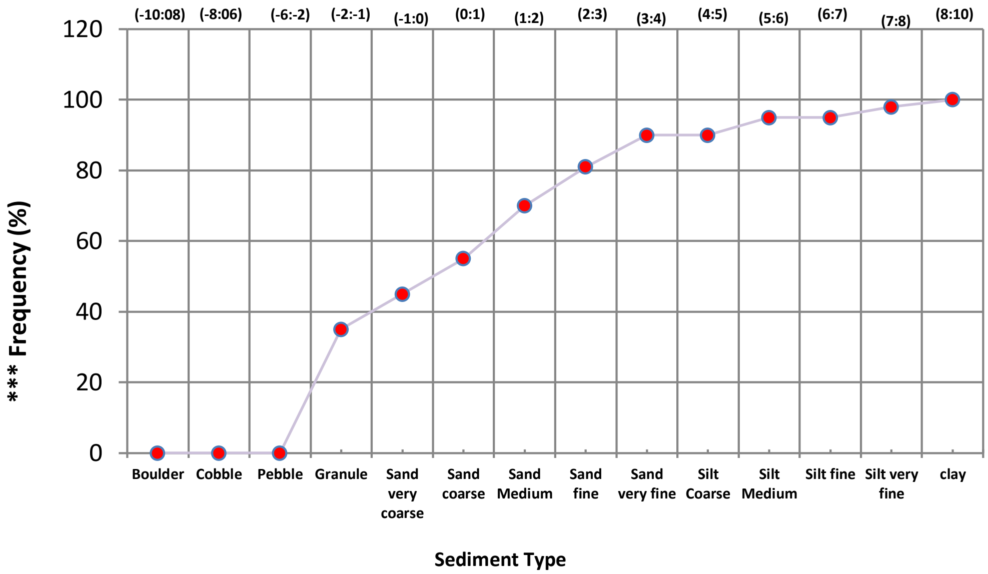


Figure 8. Cumulative curve with Phi scale

Statistical Parameters

The mean value of particle size in basin B increases with respect to basin A. An increase in the mean particle size to downstream probably indicates the significant role of sediment entry from the Ahar branch into the main channel. The sub-branches are able to carry coarse-grained sediments because of their high bed slope. The sorting of the sediments is very bad and varies in the study range 2.12 phi to 3.83 phi. By increasing distance from the upper reach of the river, the degree of sorting gets better.

Table 6. Statistical parameters of sediments of basin B of the Jajrood River

Parameter	Value	Description
Mean particle size by Phi (MZ)	- 1.116	Coarse-grained particles
Inclusive Graphic. Std. Dev	3.830	Very bad sorting
Inclusive Graphic Skewness	-0.015	Close to symmetry
Kurtosis	0.901	Medium kurtosis (Mesokurtic)

The kurtosis of the sediment to downstream has different variations. The sediment samples studied in the study area have positive kurtosis and vary range 0.715 to -0.015. Negative kurtosis in river environments is abnormal, indicating separation and washing of fine particles in the area.

Basin B of the Jajrood River is located downstream of basin A. The process of energy changes in this part of the Jajrood River Canal evaluate by the results of field observations and morphoscopic study.

Table 7 - Distribution of components of fine-grained sediments under binocular microscope

other%	**Rubble%**	**Opauqe%**	**Quartz%**	**Feldspar%**	**Muscovite%**	**Biotite%**	**Destructive Lime**	**Skeletal crumbs%**	**Sample no.**
-	30	4	4	5	2	1	52	-	B-1
-	30	5	5	7	1	1	53	-	B-2

Mineralogy and morphology of sediment

Half of the particles percentage of all samples of basin B of the Jajrood River are carbonate and destructive lime type which is due to the presence of limestone formations in the basin. Semi-round to round sediment grains in this section is due to the distance from the source area, but due to the addition of sediment of sub-branches a percentage of sediment particles are with low roundness and angular roundness can be identified in the study area.

Basin C of the Jajrood River

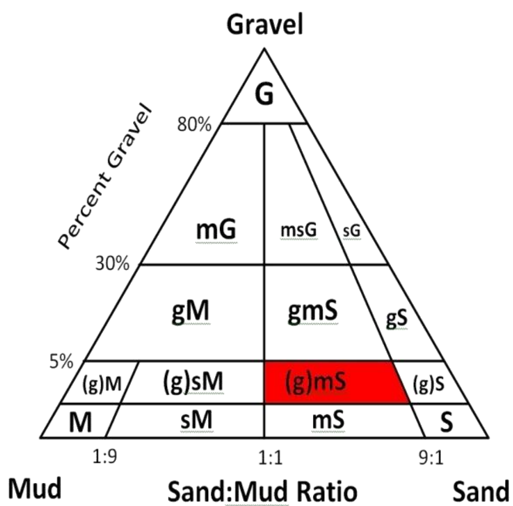
One of the reasons for the separation of this section from the upper and lower sections of the Jajrood River is the changing nature of the river and the change in the fining process of the particles from upstream to downstream. In June 2018, in Amin Abad and Rudak village area on the Zardband-Fasham road due to heavy rainfall, part of Rudak region slopes due to loosening of soil and their movement by landslide (gravity force) towards the river channel and the road, a strong flood happened. As a result of this flood, a large volume of sediments related to the Karaj Formation, including shale and tuff, was washed by the flood and carried it as a mass (rocks, mud and trunks of trees, etc.).

According to the results of texture, the sediment type in this section is a muddy sand with a bit of gravel; the details of the results are as follows (Fig. 14).

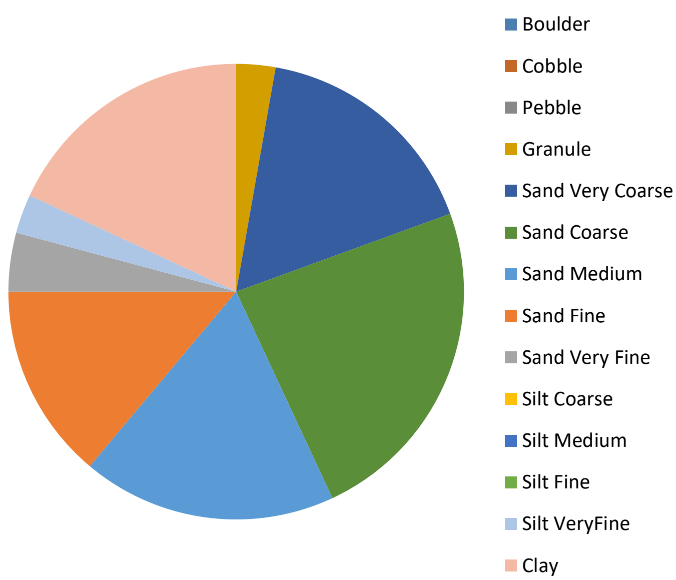
Gravel Cent: 1.562 Sand Cent: 84.034 Mud Cent: 14.404

Weight of >63:164.370 Weight of <63: 27/660 Total Weight:192.030

Folk Diagram



Pie Diagram



Sediment type: Slightly gravelly muddy sand

Fig.9 - Sediment type of basin C in Folk and circular diagram

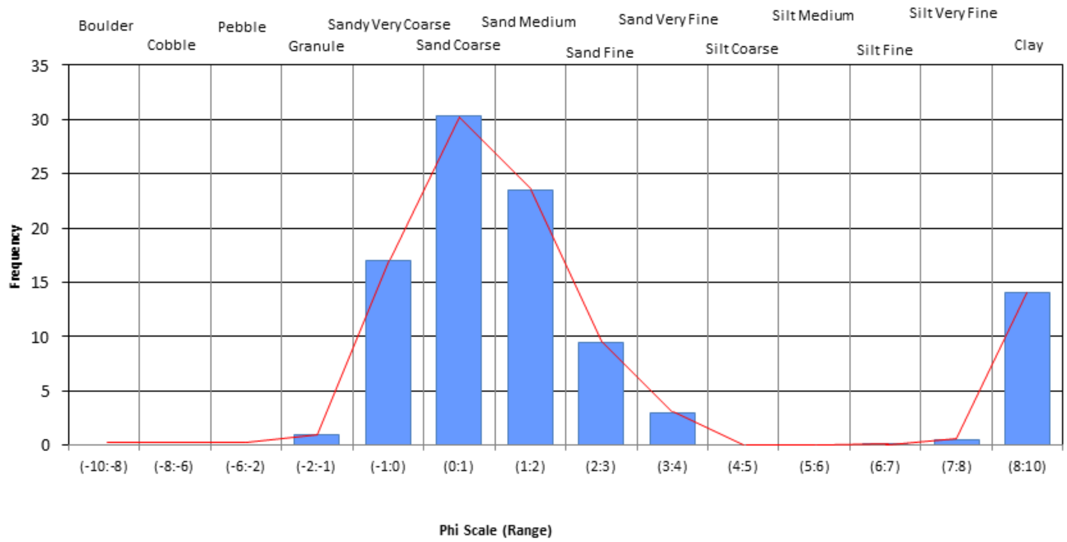


Figure 10. Cumulative curve with Phi scale

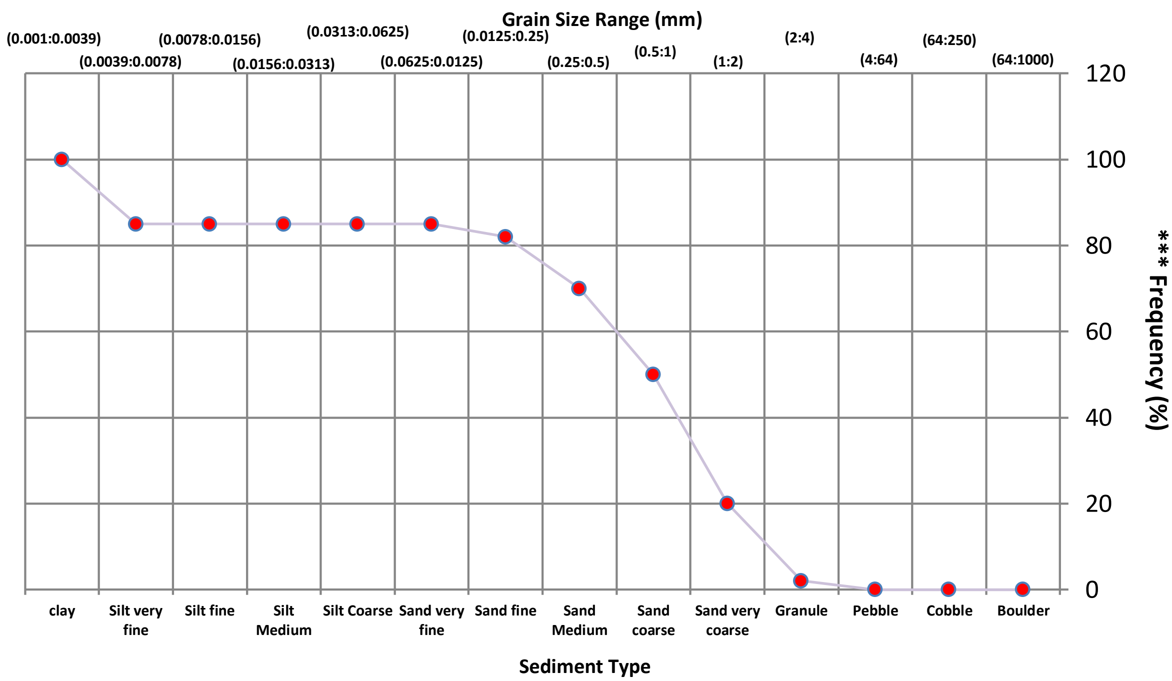


Figure 11. Cumulative curve with millimeter scale

Cumulative curve

In this section, a cumulative curve is drawn with two mm scales and a Fi scale. The slope of the curves in these curves is a function of standard deviation or sorting. The slope of the line in this curve is higher than in sections A and B, and the standard deviation is lower but the sorting is still very poor.

Statistical Parameters

The mean particle size of basin C increases with respect to A and B basins, which is not a natural change in section C because it is located downstream.This particle size change is due to the enterning fine and coarse-grained sediments into the main channel.

Sorting of the sediments is very bad and in the study range the standard deviation varies from 2 phi to 2.33phi.This decrease is also due to entering fine-grained and coarse-grained sediments into the main channel. The Kursosis of the sediments to downstream has different variations. The sediment samples studied are in the positive Kursosis at the range 0.45 to 0.85 phi. Evaluation of mean, kurtosis and sorting in sediments of section C of the Jajrood River is as follows:

Table 8. Statistical parameters of sediments of basin C of the Jajrood River

Parameter	Value	Description
Mean particle size by Phi (MZ)	0.392	Fine-grained particles
Inclusive Graphic. Std. Dev	2.339	Very bad sorting
Inclusive Graphic Skewness	0.457	Extreme skewness towards the fine particles (abundance of fine particles)
Kurtosis	1.910	Very Leptokurtic

Mineralogy and morphology of sedimentary grains

According to morphoscopic studies in the C basin of the Jajrood River, it indicates a high percentage of coarse sediments that indicate flooding effects on the river channel. According to Table 5, sample C-2 has some skeletal fragments. These skeletal fragments are likely to have been washed away from the formations by floods.

Overally in this area the percentage of clastic grain is about twice that of carbonate grains. By comparing the amount of particles and the constituents of sediments in basin C with the amount of particles in upstream sections of the river (A and B), it can be concluded that the flood caused a change in the percentage of sediment components in the river.

Cumulative curve

In this section, a cumulative curve is drawn with two mm scales and a phi scale. The slope of the line of these curves is a function of standard deviation or sorting. The slope of the line in this curve is higher than that of sections A and B, with a lower standard deviation but the sorting is still very poor.

Table 9. Percentage of constituents of fine-grain sediments

others%	**Rubble%**	**opaque%**	**Quartz%**	**Feldspar%**	**Muscovite%**	**Biotite%**	**Destructive Lime**	**Skeletal crumbs%**	**Sample no.**
-	45	4	7	4	2	3	35	-	**C-1**
-	50	4	7	2	1	4	30	2	**C-2**

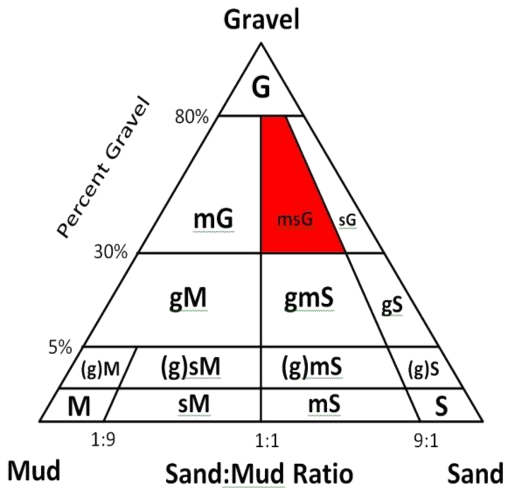
Basin D of the Jajrood River

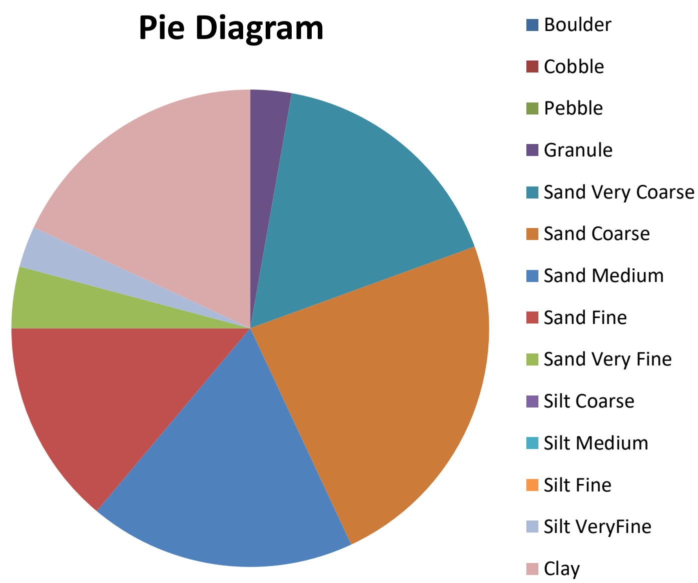
The river width of the Jajrood in Basin D increase and has undergone many changes. In order to reduce the volume of sediment entering the lake, Short embankment has been constructed along the river channel and due to the reduction in river energy, organic matter is visible along the river channel margins.

In the study area and after the construction of the Short embankments along the Jajrood River, we see longitudinal dams and sometimes transverse dams in the river channel. This is due to a decrease in energy, a decrease in the river slope in the junction to lake of the Latiyan dam. On the base of granulometry results in this basin, sediment type is Muddy sand gravel that details the results as follows.

Gravel Cent: 60.196 Sand Cent:22.188 Mud Cent:17.615
Weight of >63:428.400 Weight of <63: 91.600 Total Weight: 520.000

Folk Diagram





Sediment type: Muddy sandy gravel

Figure 12 - Sediment type of basin D in Folk and circular diagram

According to field observations in basin D of the Jajrood River, this area is a braided river and the particle size of the riverbed sediments from cobble to silt and Clay are identified with rounded to angular shape.

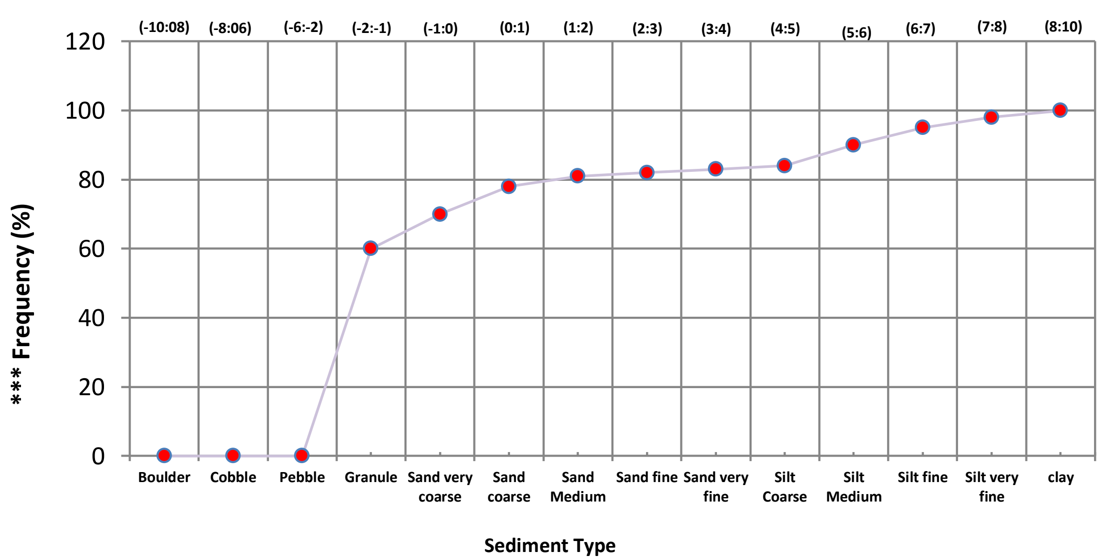


Figure 13. Cumulative curve with Phi scale

Statistical Parameters

According to the laboratory studies on sediments of basin D of the Jajrood River, the following results have been obtained.

Table10. Percentage of constituents of fine-grain sediments

Parameter	Value	Description
Mean particle size by Phi (MZ)	-1.898	Coarse-grained particles
Inclusive Graphic. Std. Dev	4.156	Extremely bad sorting
Inclusive Graphic Skewness	0.640	Moderate skewness towards the fine particles (abundance of fine particles)
Kurtosis	1.01	Moderate kurtosis

The mean value of particle size in basin D decreases relative to basin C. This decreasing trend from upstream to downstream of the river indicates a natural trend in the study area.

Sediment sorting was extremely poor and varied in the studied range from phi 3 to phi 4.65. Undoubtedly, the floods have had a significant effect on increasing the standard deviation of sediment in this area due to the transport of coarse-grained sediments with silt and clay. The skewness of the sediments to downstream has different variations. The samples have the positive skewness in the range 0.25 to 0.64.

Mineralogy and morphology of sedimentary grains

Due to the location of basin D at downstream of the Jajrood River, energy has decreased in this part of the river due to the low slope and high width of the river channel. For this purpose, sediment grains are expected to have high roundness in this part of the river channel. According to morphoscopic studies of this part of the river, the following results were obtained.

Table 11 - Distribution of components of fine-grained sediments
Under binocular microscope

Others%	**Rubble%**	**opaque%**	**Quartz%**	**Feldspar%**	**Muscovite%**	**Biotite%**	**Destructive Lime**	**Skeletal crumbs%**	**Sample no.**
5	25	5	8	4	2	2	49	-	**D-1**
9	27	5	10	0	0	3	47	-	**D-2**

4. CONCLUSIONES

In this study, the Textural changes of sediments of the Jajrood River were investigated as follows from upstream to downstream.

Basin A

According to field observations in this area, sediment particles vary in size from coarse-grained sand to cobble and boulder with very bad sorting and particles have low angular roundness. The results of granulometry of sediments of the Jajrood River Channel in the basin at the Folk diagram (1974) have a gravel sand sedimentary type. Sediment sorting is weak and very weak and varies within the study range of 1.96% Phi to 2.34% Phi. The sediment samples in the studied area have a positive skewness in the range of 0.395 to 0.85.

Basin B

In this part of the river, according to field observations, the sediments of the channel bed are of varying sizes from coarse grained sand to cobble with very bad sorting, and the particles have angular to semi-rounded. In this part, the river has a normal course and due to the high slope, only in some areas, there are longitudinal dams. In this area, the steep slope of the Jajrood River channel prevents the formation of transverse dams in the river channel. The mean particle size of section B increases compared to section A. An increase in the mean particle size toward downstream probably indicates the significant role of sediment entry from the main Ahar branch and other sub-branches into the main channel. The sorting of the sediments is very bad and varies in the studied range of 2.12% Phi to 3.83% Phi. The sediment samples in the studied area have a positive kewness in the range of 0.715 to -0.015.

Basin C

One of the reasons for the separation of this part from the upper and lower parts of the Jajrood River is the changing nature of the river and the change in the fining process of the particles from upstream to downstream. The mean particle size of section C increases compared to sections A and B but this change is not natural. The enlarging particle size of the Sediment toward downstream is due to entering coarse-grained sediments into the main channel. Sorting of the sediments is very bad and in the study area, the standard deviation varies from 2% Phi to 2.33% Phi. This decrease is also due to entering fine-grained and coarse-grained sediments into the main channel. The sediment samples in study area have the positive skewness in the range 0.45 to 0.85.

Basin D

The width of the river in basin D increase, which is the lower reach of the river at the junction to the Latian dam. The mean particle size of basin D decreases relative to basin C. This decreasing trend of the mean of sediment particles in the river channel from upstream to downstream is normal. Sediment sorting was extremely poor and varied in the studied range from 3 phi to 4.65 phi. Undoubtedly, the floods had a significant effect on increasing the standard deviation of sediment in this area due to the transport of coarse-grained sediments with silt and clay. The sediment samples have the positive skewness in the range 0.25 to 0.64.

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