The study of Discontinuous Exponential Increase of Grain Size in Polrud Streambed Sediments, North of Iran

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Abstract: - Polrud River is a sandy-gravelly river with single bed load channel that springs from Alborz mountain ranges and flows toward Caspian Sea. In order to determination of main sedimentologic characteristics, textural properties of streambed sediments are discussed in this study. For such purpose, representative samples were collected from different sites of mentioned basin and were prepared for textural analyses. Textural studies shows that the sediments concerning different parts of this alluvial system are poorly to moderately sorted and the sorting of sediments to be get better toward downstream. Most samples show positive skewness that is characteristic of turbulent flows and also indicate lack of time for winnowing of fine sediments beside intense changes of flow during different time interval. Some negative skewness is also observed that is interpreted as a result of high flow regime in straight paths of river system that wash fine sediments and increase coarse grain portion of sediment. The present study shows that discontinuous exponential increase in values of mean and grain size median are recorded downstream. Grain size decrease from feeding tributaries toward downstream and increase again due to special geologic situation of region and closeness of source area and also inflows of numerous tributary into main channel and this change in grain size is as discontinuous exponential increase. This property is in contrast with general trend of decreasing of grain size toward downstream. Perhaps this special characteristic in Polrud River can be as a pattern for studying and interpretation of streambed sediments in past time.

Key-words: discontinuous exponential increase, grain size, streambed sediments, Polrud River; sandy-gravelly river, textural analyses, alluvial system

1 Introduction

All rivers transport sediment as well as water. Riverine environments are complex systems of erosion, sediment transportation and deposition which give rise to great variety of landforms. Fluvial systems range from alluvial fans, through braided and low sinuosity stream networks to meandering(high sinuosity) rivers. Their sediments range from the coarsest conglomerates through sandstones to mud rocks. Understanding of behavior and nature of rivers require detail notice of sedimentologic characteristics of streambed sediments[1]. Textural analyses of streambed sediments in different parts of river, indicates properties of flow and its changes[2]. On the other hand study of river sediments and understanding of flow regimes is necessary for design and programming of water resources, specially dam reservoir and its implementation. The Polrud river with sandy-gravelly bed sediments, situated in Gilan Province, North of Iran, known as dynamic fluvial system that transport sediments, erodes existing soil and rocks, and creates recent deposits. In order to regulate water as well as control of flood hazard during winter and spring a dam planned to be

constructed on Polrud River. Peripheral sources defined as series of channels with distinctive textural characteristics, that caused by textural variance along principle channel[3]. Debris slide and major channel erosion are the most important side fluxes of active channel[4]. Since the river carries substantial amount of sediment inflow, the reservoir will face significant volume of sediment deposition, which diminish the life of the reservoir. So sediments in the Polrud River are discussed in this study. Grain size analysis can be used to distinguish between sediments of different environments and to give information on the depositional processes and flow conditions[5]. Grain size distribution in streambed sediment is related to source rock specification, weathering processes, mechanical abrasion and grains selective sorting during transportation[6]. Main objective of this study is determination of detailed textural characteristics of sediments from different portions of river and analyses of its change trends. Analyses of river flow regime is possible based on textural properties of river sediments[7].

2 Description of study unit

Case study was carried out on the Polrud river basin. The study basin is located in north of Iran and southern part of Caspian Sea(Fig.1). Polrud river basin covers an area about 1765 km^2 and lies between 36º, 33" to 37º, 13" N and between 49º, 36" and 50º, 34" E. Polrud springs from Alborz ranges and flows toward Caspian Sea. The river passed through tow steep reaches before flowing through a relatively flat gradient toward its mouth at Caspian Sea. These reaches that are shown in figure1 are called Chakrud and Polrud. Moderate annual precipitation for the drainage basin is about 856.6 mm and fairly low mean discharge of the river is about 14.17m^3/s[8].The river has nivo-pluvial regime. This flow regime has been clearely suggested in most of rivers that discharge into southern Caspian Sea[9].

3 Study methods

In this study 57 streambed sediment samples were collected from tributaries and main channel, exposed bars, river banks and channels(Fig.2). In order to study of main textural characteristics of sediment samples, they prepared for grain size analyses. Grain size analyses of samples carried out in three categories; gravels by direct measurement with a measurement tape, sands by sieving[10] and fine grains(silt/clay), can be made with settle out methods which measure the deposition rate of grains through a column of water. Once the grain size distribution has been obtained then the sediment can be characterized by several parameters: grain size mean, mode, grain size median, sorting and skewness. The parameters are often deduced from graphic presentation of the data, but an alternative is the method of momentary, whereby the parameters are calculated directly from the size data that can be applied relatively with an electronic calculator or computer. For graphic presentation the histogram, smoothed frequency curve and cumulative frequency curve are plotted. Trends of the parameters and its variation are distinguished and relevant results are discussed.

4 Results and Interpretation

Major sedimentologic characteristics are discussed and textural parameters include of grain size mean, mode, grain size median, sorting and skewness are calculated. For easiness of study and survey of probable differences and also according to geographic distribution of sampling sites, streambed sediments are discussed in three individual groups; Chakrud reach, Polrud reach and main reach(from junction point of Chakrud and Polrud to river mouth at Caspian Sea). The Calculated textural parameters of these reaches are shown in tables 1 to 3. Study of textural parameters shows that all sediments from different parts of the river, except of channel's coarse grains, are poorly sorted and sorting improves downstream. Immature texture

reflects that flow regime in the river do not permit to form natural sorting of the sediments. In other words, whereas the river is permanent but shows the properties of a temporary river and this condition reflects high turbulence water flow in different parts of river and intense change of flow regime during the time. These conditions along with downstream mean increasing show continuous entrance of sediments from collapse of river bank or from tributaries that connect to the main channels. On the other hand change in the morphology of steep slop river flanks in downstream also play a controlling role on sorting and grain size mean. Discontinuous exponential increase of grain size mean and median in main channel(Figs3,4), clearly reflect the rule of tributaries in supply of sediments. Of course this trend is coinciding with trend of sorting toward downstream in the main channel(Fig 5). This case is an interesting result of present study that is in contrast with general trend of decreasing of grain size toward downstream. For interpretation of ancient sandstones this property must be considered and these results can be used in groundwater and hydrocarbon exploration aspects. Another factor shows important rule of steep slop bank collapse and entrance of tributaries as source of sediment load is the polymodal(trimodal and bimodal) distribution in some sediment samples. Mixing of sediments from tow origin(tributaries and bank collapse) is the most important factor to bimodal distribution.

5 Discussion and Conclusions

Skewness of Polrud's streambed sediments is generally positive and this is a normal order in river and reflects the lack of time for winnowing of fine grains by water flow. Presence of cobbles and boulders in streambed has major rule to maintain of fine sediments in channel bed. On the other hand, turbulence of flow, feeding of river by tributaries, and abrasion and breakdown of labile particles, cause positive skewness distribution. Negative skewness in some parts of river is a typical order in riverine systems, and probably is consequence of steep slop of river channel and intense water flow. High flow regime, wash the fine particles and elevate the coarse/fine particles ratio and so creates the negative skewness. About 30 percent of Chakrud and 55 percent of Polrud sediments have negative skewness. This reflect that portions of steep slop in channel and high flow regime parts in Polrud reach is approximately tow times greater than Chakrud reach and rule of this reach in turbulent flow is greater in the river. Larger grain size of streambed sediments and morphology of the region, also emphasize on this results. Textural characteristics of river show that bank collapse and sliding of river flanks, are two most important sources of river load.Intense and abrupt precipitation with together increase bank erosion and turbulence of flow. It may cause by development of temporary river properties in some streambed deposits.On the other hand, tranquil condition specially in downstream(from junction point of tow reaches), cause appearance of permanent river characteristics.

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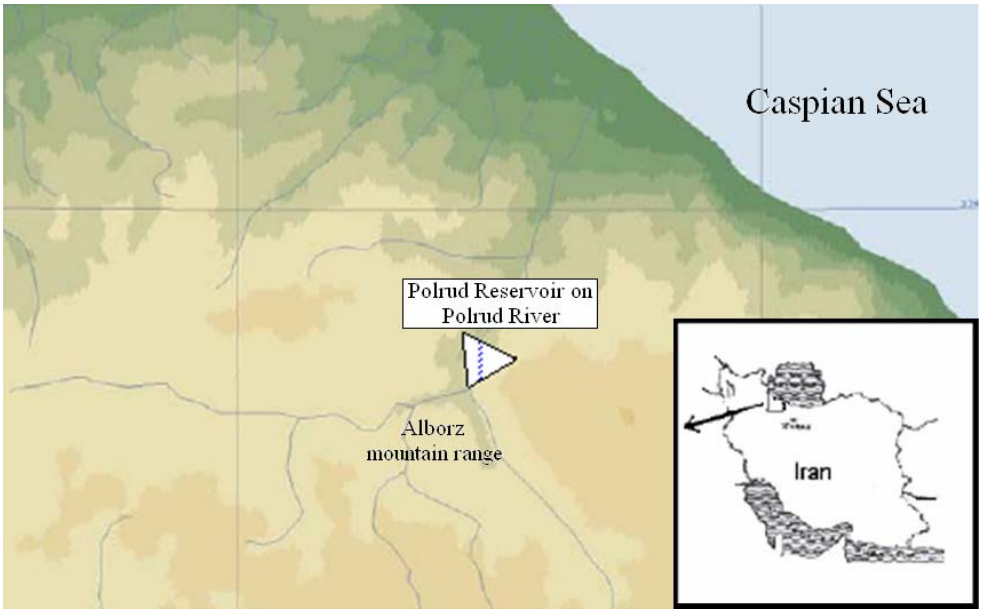

Figure 1. Geographic coordinates and relational roads to study area.

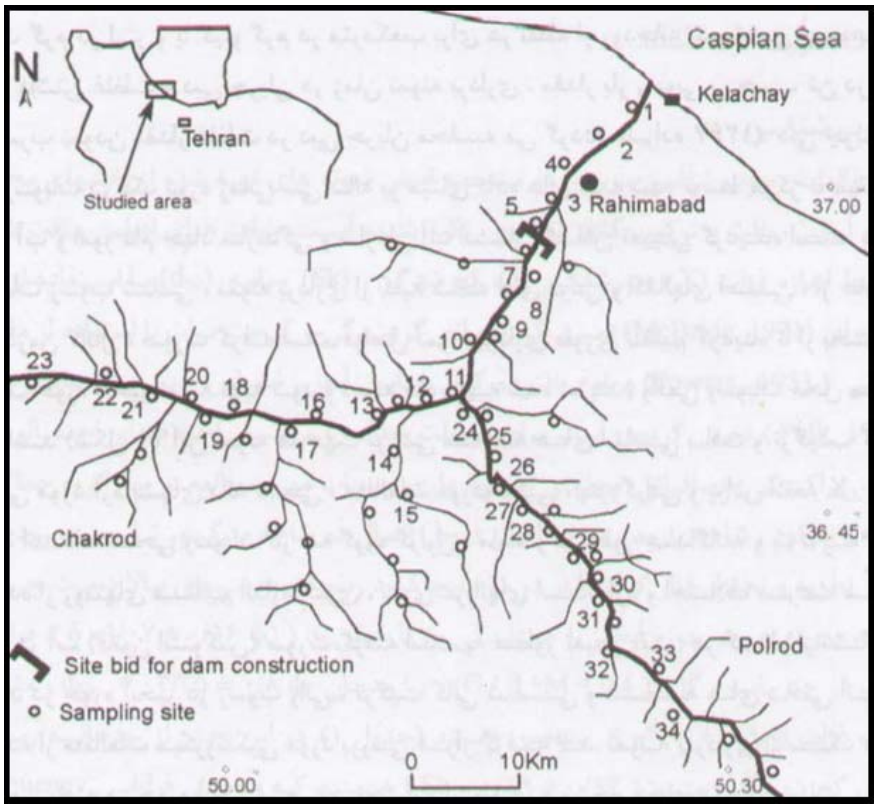

Figure 2. Location of sampling sites(just sites that distinct with number are pointed in text).

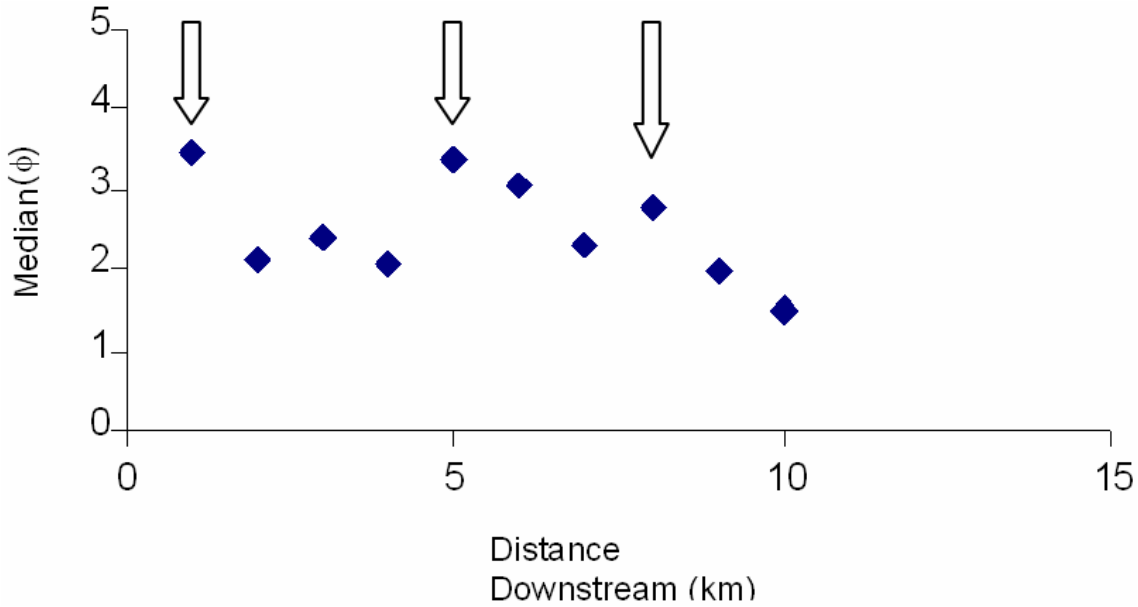

Figure 3. Trend of median changes via distance(arrows are tributary entrance).

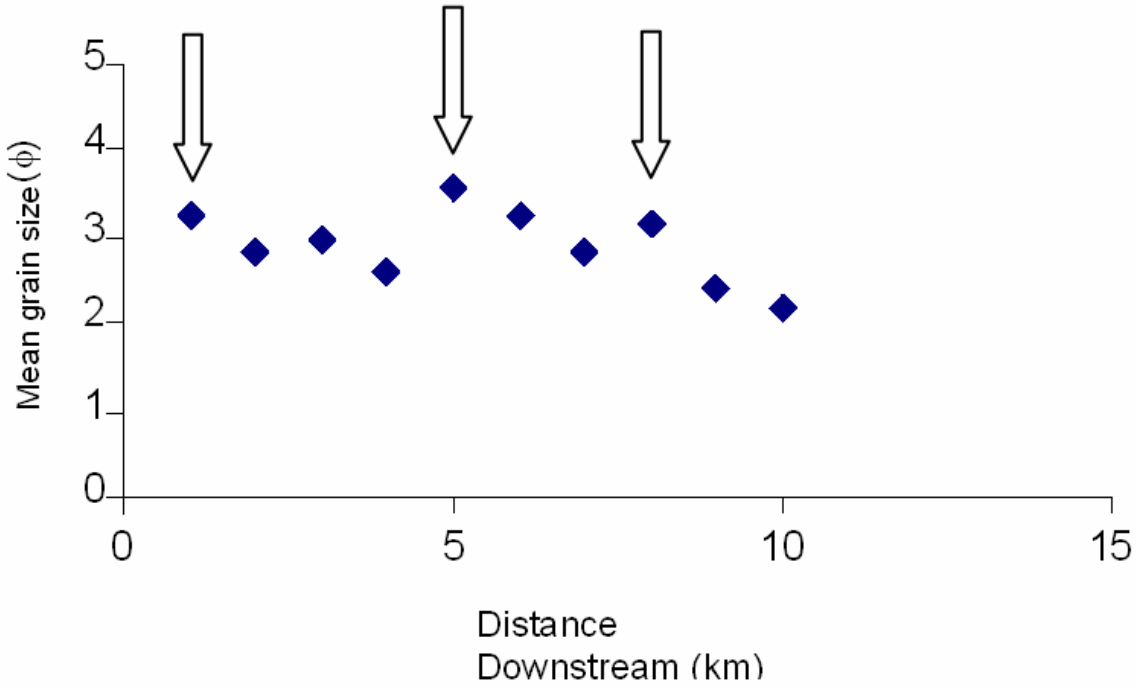

Figure 4. Trend of mean grain size changes via distance(arrows are tributary entrance).

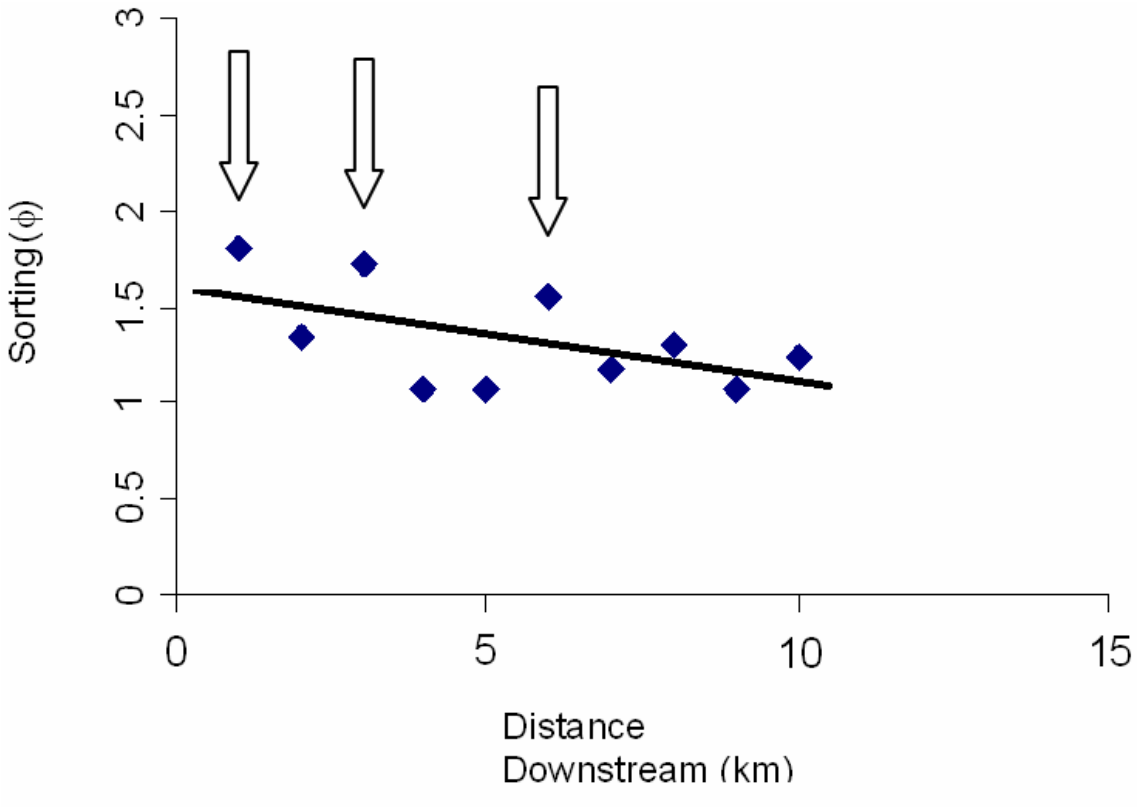

Figure 5. Trend of sorting changes via distance(arrows are tributary entrance).

Table 1. Calculated textural parameters for Polrud reach.

Sample Number	X	σ	S_k	D_{50}	G/S+M
1	**2.63**	**1.24**	**0.52**	**1.5**	**1.22**
2	**2.91**	**1.08**	**-0.26**	**1.94**	**1.22**
3	**2.58**	**1.52**	**-0.17**	**1.6**	**1.44**
4	**1.71**	**1.44**	**0.79**	**0.53**	**3**
5	**1.2**	**1.47**	**0.06**	**1**	**1.44**
6	**3.8**	**1.3**	**0.4**	**2.76**	**1.44**
7	**1.91**	**1.55**	**0.27**	**0.82**	**1.44**
8	**3.41**	**1.17**	**0.62**	**2.3**	**1.44**
9	**2.48**	**1.92**	**0.15**	**1.47**	**5.66**
10	**3.2**	**1.84**	**-0.19**	**2.26**	**5.66**

Table 2. Calculated textural parameters for Chakrud reach.

Sample Number	X	σ	S_k	D_{50}	G/S+M
11	**3.94**	**1.56**	**-0.22**	**3.03**	**2.33**
12	**2.43**	**1.8**	**-0.02**	**1.59**	**2.33**
13	**2.13**	**1.8**	**0.1**	**1.23**	**2.33**
14	**2.65**	**1.8**	**0.42**	**1.35**	**1.44**
15	**2.77**	**1.41**	**0.47**	**1.67**	**1.44**
16	**4.31**	**1.07**	**0.43**	**3.35**	**2.33**
17	**3.53**	**1.24**	**0.43**	**2.53**	**1.5**
18	**3.84**	**1.43**	**-1.05**	**3.23**	**3**
19	**3.49**	**1.72**	**-0.49**	**2.7**	**2.33**
20	**2.7**	**1.53**	**0.31**	**1.59**	**3**
21	**2.33**	**1.53**	**0.13**	**1.35**	**4**
22	**2.84**	**1.32**	**0.01**	**1.76**	**5.66**
23	**3.12**	**1.07**	**0.27**	**2.06**	**5.66**

Table 3. Calculated textural parameters for reach that begin from junction point to river mouth at Caspian Sea.

Sample Number	X	σ	S_k	D_{50}	G/S+M
24	**3.6**	**1.71**	**0.33**	**2.38**	**1.44**
25	**3.33**	**1.6**	**-0.72**	**2.59**	**1.5**
26	**3.54**	**1.37**	**-0.36**	**2.59**	**1.22**
27	**2.83**	**1.34**	**0.77**	**1.59**	**2.33**
28	**3.4**	**1.35**	**0.71**	**2.12**	**1.22**
29	**1.42**	**1.62**	**0.76**	**0.86**	**2.33**
30	**2.86**	**1.39**	**-0.21**	**1.88**	**2.33**
31	**2.53**	**1.8**	**0.07**	**1.51**	**0.43**
32	**3.57**	**1.37**	**-0.09**	**2.59**	**1.44**
33	**3.1**	**1.47**	**0.51**	**1.94**	**1.44**
34	**3.95**	**1.8**	**-0.29**	**3.47**	**2.33**

(In three above tables: X= grain size mean, σ = sorting, Sk= skewness, D_{50}= grain size median, G/S+M= gravel per sand and mud(silt and clay) ratio).