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Grain Size Characteristics of Bed Sediments of Rivers and Ponds in a Valley-filled Intermontane Basin in the Eastern Himalayas

MD. ABDULLAH KHAN* and SARFARAZ AHMAD
Department of Geology, Aligarh Muslim University, Aligarh U.P. India
*E-mail: abdullah.amu2000@gmail.com

Abstract: Grain size analysis was carried out for the bed sediments from the rivers and standing water bodies (SWBs) in the Imphal valley of Manipur in the Eastern Himalaya. The results show that the bed sediments from rivers are mostly medium sand but at some places the bed sediments are fine to coarse sand. There is significant difference in the Kurtosis and Skewness of the bed sediments from the rivers and SWBs. However, in both the groups the bed sediments do not show any significant difference in sorting which may be due to the low energy conditions of the drainage system in the valley.

Keywords: Grain size, Bed sediments, Valley-filled intermontane basin, Eastern Himalaya, Imphal River, Manipur valley

INTRODUCTION

Grain size parameters are widely used as indicators of different sedimentary environments (Friedman, 1961, Duna, 1964). These mainly depend on the factors like availability of source material, medium of transport action, physiography and geomorphology of the area including winds, waves, climate and long shore current (King 1972; Swift 1976).

Several studies on Quaternary intermontane valley fill sedimentation have been carried out in many parts of the worlds in recent times (Beaty, 1963; Church and Ryder, 1972; Fort et al, 1979; Sharma et al; 1980). Most of these works were based on glacial fed valley fill deposits (Church and Ryder, 1972; Jackson et al. 1982; Rust, 1973; Ryder, 1971). In India, the studies on Quaternary valley fill deposits are mainly confined to the Western and Central Himalayas in the Northern part of the country (Tandon, 1981; Valdia et al; 1984; Nossin, 1971). A few works have been done in the Eastern Himalaya (Sinha and Roy, 1980). Most of these works are based on the glacial fed valley-fills.

The studies of the sedimentological characters are useful to decipher the palaeoclimatic depositional history of the study area. But work in the Eastern Himalaya is very limited due to logistic problems even though the climatic conditions of this region are different from those prevailing in the Western and Central Himalayas. Different climatic conditions also effect different environments of deposition of sediments.

The present study aims to decipher the inter-relationship of grain size variation in the depositional environments due to the combined effects of several geological agents in the (intermontane) valley-fill fluvio-lacustrine sedimentation in one of the intermontane valleys in the less studied parts in the Eastern Himalaya. This study will not only fill the data gap but also ignite interest in many workers to work in a region which has different climatic conditions with different sets of environments as compared to the more studied counterparts of the western and central Himalayas

STUDY AREA

Manipur, a state of India, lies in the northeastern part of the country. It is surrounded by Myanmar, in the east and southeast, Assam in the west, Nagaland in the north, and Mizoram in the southwest. The study area is mainly confined to the major parts of the Imphal valley, also known as Manipur valley, which lies in the central part of the state. The study area is bounded by 24°16'N and 25°02'N latitudes and 93°41'E and 94°09'E longitudes and covers an area of about 1800 sq. kms. This valley is an elongated, oval shaped, intermontane valley with elevation ranging from 746 m to 850 m above the mean sea level (MSL) with an average elevation of about 780 m above the MSL.

The Imphal valley is traversed by important rivers of the state of Manipur namely Imphal (Manipur) River, Iril River, Thoubal River, Wangjing River etc. The Imphal River flows from north to south and is joined by its tributaries namely Iril River, Thoubal River and Sekmai River at different places. These rivers along with private and community ponds and lakes of varying sizes dotting the valley landscape provide important sources of surface water for use in domestic and municipal purposes.

The study area covers major part of the Imphal valley, a small valley lying within the Disang-Barail

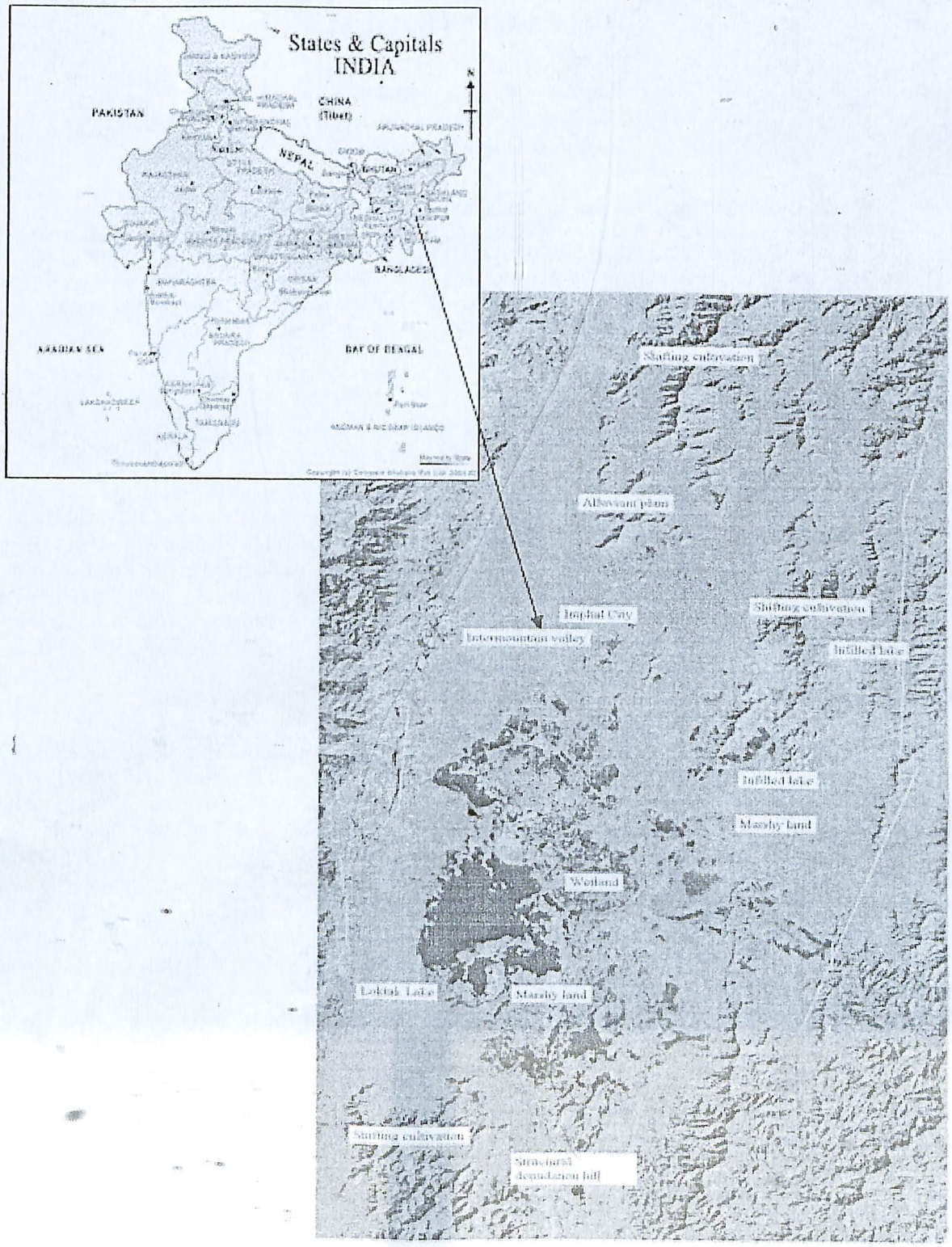

Fig. 1. Location map of the study areas.

Flysch Basin in the central part of the state. This valley was formed as a result of the tectonic and structural evolution of the Indo-Myanmar Range, IMR (Ibotombi, 1993). The valley is covered by Quaternary alluvium Deposits of 40-50m thickness (Ibotombi, 1993). The sediments are derived from the surrounding Disang and Barail hills and are dark-gray to black clay, silt and sand. Clay, sand, gravel, pebble and boulder deposits are also found in the foothills and in old river terraces.

The climate of Imphal valley varies from sub-tropical to temperate. However there is appreciable spatial variation with contrasting weather conditions in various seasons. Highest temperature of about 30°C-35°C is recorded during southwest monsoon and minimum average temperature of about 4°C is recorded during winter (December-January). The average annual precipitation varies from 150 cm to175.8 cm with maximum intensity during July-August. Since rainfall is associated with monsoon, there is irregularity in seasonal rainfall.

METHOD OF STUDY

Twenty two (22) bed sediment samples from two different depositional environments of rivers and standing water bodies (SWBs) which include lakes and ponds, were collected from the study area through grab sampling of the sediments beneath 1 feet deep after removing 6 inch x 6 inch area of the top soil. The samples were dried and approximately 100 gms. of each sample were disintegrated and subjected to sieving for 10 minutes in a Ro-Tap sieve shaker using ASTM standard sieves. The physical data representing the size distribution of each sample were computed to get the graphic statistics: Mean, Standard Deviation, Skewness and Kurtosis as per Folk and Ward (1957) method using GRADISTAT software.

RESULTS AND DISCUSSION

Table 1 shows the values of some of the important parameters attained by graphic method of twenty two (22) sediment samples collected from different sampling points in the rivers and standing water bodies from the study area (Fig.2).

Mean Size (Mz)

Mean size indicates the average size of the sediments. In terms of energy, it indicates average kinetic

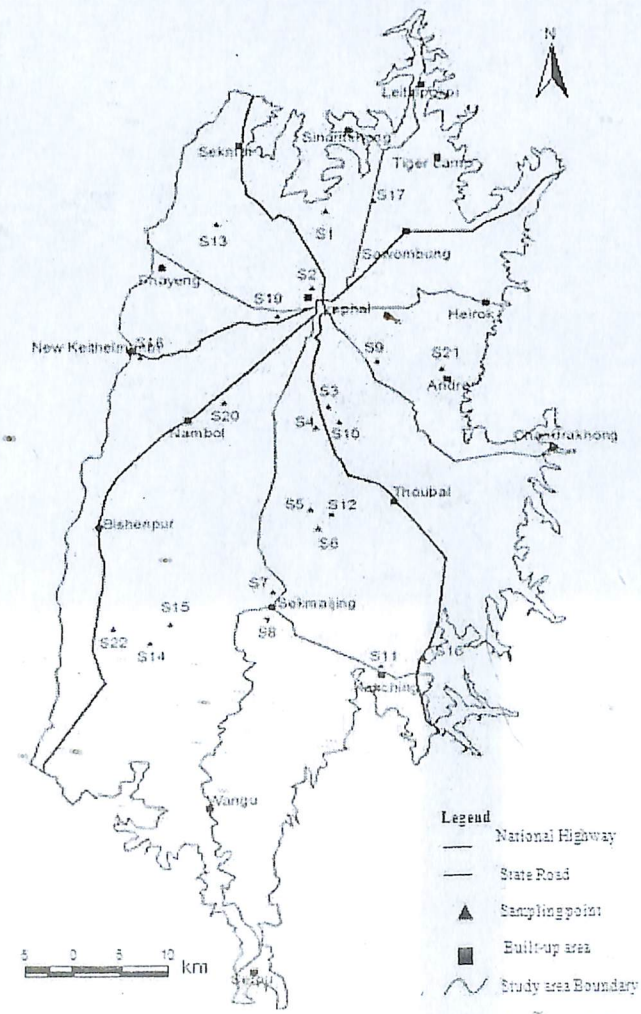

Fig. 2. Location map of bed sediment samples in the study area (adapted from ZASICM, 2007).

Table 1. Sedimentological characterstics of the bed sediment from river and ponds in Imphal valley

S. No.	Latitude	Longitude	Location	Type of water body	MEAN SIZE	Description	Sorting	Description	Skewness	Description	Kurtosis	Description
1	24°52' N	93°56' E	Achanbigei	River	1.6	MS	1.3	PS	0.3	CSK	0.77	PK
2	24°48' N	93°57' E	Hatta	River	2.48	FS	1.16	PS	0.25	CSK	1.75	VLK
3	24°43' N	93°56' E	Lilong.BJ(Im)	River	1.48	MS	1.39	PS	0.17	CSK	0.51	VPK
4	24°42' N	93°56' E	Lilong.AJ(Im)	River	2.77	FS	1.02	PS	0.09	SYM	0.64	VPK
5	24°39' N	93°55' E	Irong.BJ(Im)	River	-0.26	VCS	-0.16	VWS	0	SYM	0.74	PK
6	24°38' N	93°54' E	Irong.AJ(Im)	River	-0.26	VCS	-0.11	VWS	0.68	FSK	-2.3	VPK
7	24°33' N	93°54' E	Sekmaijing.BJ(Im)	River	1.9	MS	1.64	PS	0.31	VCSK	0.58	VPK
8	24°33' N	93°53' E	Sekmaijing.AJ(Im)	River	1.26	MS	1.27	PS	0.2	CSK	0.55	VPK
9	24°45' N	93°59' E	Irilbung.(Ir)	River	1.21	MS	1.25	PS	-0.1	CSK	0.62	VPK
10	24°42' N	93°56' E	Lilong.BJ(Ir)	River	2.77	FS	1.02	PS	-0.09	SYM	0.64	VPK
11	24°33' N	93°56' E	Kakching(SekmaiR)	River	1.29	MS	1.3	PS	-0.11	CSK	0.56	VPK
12	24°38' N	93°55' E	Irong(TblR)	River	-0.27	VCS	0.27	VWS	0.6	VFK	-3.59	VPK
13	24°52' N	93°52' E	Phumlousiphai(SmR)	River	1.14	MS	1.15	PS	-0.29	CSK	0.73	PK
14	24°31' N	93°49'E	Takmu	Lake	1.12	MS	1.35	PS	-0.05	SYM	0.7	PK
15	24°31' N	93°44' E	Loktak	Lake	1.37	MS	1.47	PS	-0.29	CSK	0.68	PK
16	24°30' N	94°01' E	Sora	Pond	1.22	MS	1.17	PS	-0.13	CSK	0.68	PK
17	24°53' N	93°59' E	Khundrakpam	Pond	-0.27	VCS	0.17	VWS	0.64	VFSK	-0.62	VPK
18	24°46' N	93°48' E	Moidangpok	Pond	1.67	MS	1.53	PS	0.04	SYM	0.73	PK
19	24°48' N	93°54' E	Takyel	Pond	1.34	MS	1.36	PS	-0.01	SYM	0.79	PK
20	24°43' N	93°51' E	Utlou	Pond	1.15	MS	1.13	PS	-0.09	SYM	0.7	PK
21	24°44' N	94°03' E	Andro	Pond	1.41	MS	1.48	PS	-0.08	SYM	0.67	VPK
22	24°34' N	93°47'E	Project gate(LL)	Lake	1.35	MS	1.41	PS	-0.1	CSK	0.66	VPK

MS-Medium sand
VWS-Very well sorted
VCSK-Very coarse skewed
VLK - Very Leptokurtic
IrR-Iril River
LL-Loktak lake

FS-Fine sand
CSK-Coarse skewed
VFSK-Very fine skewed
BJ-before junction
TblR-Thoubal River

VCS-Very coarse sand
SYM-Symmetrical
PK – Platykurtic
AJ-after junction
SR-Sekmai River

PS-Poorly sorted
FSK-Fine skewed
VPK - Very Platykurtic
ImR-Imphal River
SmR-Singdamaril River

energy/velocity of the agent of deposition (Sahu, 1964). The mean size of the sediments of the river beds varies from –0.27 (very coarse sand) to 2.77 (fine sand) with and average of 1.32 (medium sand). More than 77% of the river bed sediment samples are medium sand where as the percentage of fine and very coarse sand are equal at 11.11% each, the bed sediment samples from the SWB (Standing Water Body) varies from –0.27 (very coarse sediment) to 1.67 (medium sand) with an average of 1.15 (medium sand) fall in the medium sand category, while very few samples belong to coarse sand. In samples collected from the beds of SWBs show mainly medium sand with less variation than the riverbed sediments. The variation in grain size of the riverbed sediment samples is due to the hydraulic variation at different places in course of the rivers. However the sediments from the bed of the SWB show uniformity in the hydraulic conditions and therefore they are dominated by medium sand.

Standard Deviation (σ)

Standard deviation (σ) of the sediment samples is worked out to know the sorting of the sediments. It indicates the fluctuation in the kinetic energy/velocity of the agent of deposition (Sahu, 1964). The (σ) for the river bed sediments varies from –0.16 (very well sorted) to 1.64 (poorly sorted) with an average value of 0.96 (moderately well sorted). More than 76% of the samples are poorly sorted while the remaining are very well sorted. For the SWB bed sediments, (σ) value varies from 0.17 (very well sorted) to 1.53 (poorly sorted) with an average of 1.23 (poorly sorted). In SWB bed sediment sample group shows that more than 88% of the samples poorly sorted while the remaining 11.11% of the samples are very well sorted. In both the groups, poorly sorted grains dominate. The reason may be due to the low energy conditions prevailing in the local rivers and SWB's, where sorting has not been affected.

Skewness (Ski)

Skewness is one of the important parameters of the grain size analysis. It measures the asymmetry of a frequency distribution. The skewness of the river bed sediments varies from –0.29 (coarse skewed) to 0.68 (fine skewed) having an average of 0.15 (coarse skewed). More than half the samples of this group are coarse skewed followed by 23.07% symmetrically skewed and very fine skewed sediments in equal share. For the SWB bed sediments skewness varies from –0.29 (coarse skewed) to 0.64 (Fine sand) with an average of –0.01 (near symmetrical). But in this group more than half the samples (55.56 %) are symmetrical followed by 33.33% coarse skewed and 11.11% very fine skewed. The coarse skewed nature of the (the) most of the river bed sediment samples is due to the selective removal of fine sediments from the river bed, while in most of the SWBs bed sediment samples the skewness is symmetrical because of prevailing low energy condition.

Kurtosis (KC)

The Kurtosis value of the riverbed sediment samples varies from –3.59 (very platykurtic) to 1.75 (very leptokurtic) with an average of 0.17 (very platykurtic). More than 69% of the samples are very platykurtic followed by 23.07% platykurtic and 7.69 very leptokurtic. For the SWB bed sediments, kurtosis value varies from –0.62 (very platykurtic) to 0.79 (platykurtic) with an average of 0.55 (platykurtic). In this group more than 66% of the samples are platykurtic and the remaining are very platykurtic in nature. The different kurtosis nature in these two groups of sediments is due to the nature of transporting agents. The very platykurtic nature of the sediment samples from the bed of rivers is due to the removal of the fine sediments by the moving water, whereas the platykurtic nature of the SWB is because of the more or less uniform distribution due to the lack of movement of the water due to low energy conditions.

Spatial Variation in bed sediments of rivers

The spatial variation of the hydrodynamic conditions of the Imphal River has a significant impact on the sedimentary characteristics of the bed sediments. The bed sediment characteristics of the river are influenced by the bed sediments characteristics of its tributaries namely the Iril River and Thoubal River especially at the points of confluence and in the downstream direction from the point of confluence.

In the upper reaches of the Imphal River, poor sorting and medium sand size characterized the bed sediment. This characteristic is maintained even after Imphal River meets Iril River at Lilong. This is because of the fact that Iril River bed sediments also have the same characteristics as that of the Imphal River and these characters are maintained in the downstream direction with more or less uniform hydrodynamic condition.

But where Imphal River is met by another tributary, Thoubal River, the bed sediments characteristics at the place of confluence and in the downstream direction is altered and the sediment characteristics of the Thoubal River become dominant. The poorly sorted fine to medium sand bed sediments of Imphal River seems to be completely obliterated by the very well sorted, very coarse sand bed sediment characteristics of the Thoubal River. This dominancy continues for some distance towards the downstream direction. This is because of the fact that, the stronger current flow of the Thoubal River with its narrower stream channel is contributing very well sorted very coarse sand to bed sediment. Further downstream, the bed sediment characteristic of the Imphal River again becomes poorly sorted medium sand.

The kurtosis and skeweness results of the rivers and SWBs suggest that the river waters selectively uptake the fine sediments from the upper reaches of the valley and from along their courses and deposit these finer sediments around the Loktak Lake region in the southern part of the valley as the flow conditions are considerably reduced near the lake. The deposition of these fine sediments around the Loktak Lake resulted in the development and expansion of swampy and poorly drained soil around the lake shown in Fig. 1.

The spatial distribution of the bed sediment characteristics of some rivers and ponds in the study area were plotted using the software, SURFER 8.1. and shown in the Fig.3. The spatial grain size distribution plot shows the decreasing grain size trends from NE to SE. This indicates dispersal of sediments in the basin.

The sorting distribution plot shows increasing trend from NE to SW. The sorting of the sediments is also observed to be affected by topographic features. The occurrence of highly unsorted sediments indicates short transportation of the sediments which originates from the alluvial fan deposits along the faulted anticline axis which forms the limit of the westward extension of the valley.

The skewness plot of the sediment grain size distribution shows that in the eastern side of the valley the sediments are coarse skewed and on the western side the sediments are fine skewed with some local

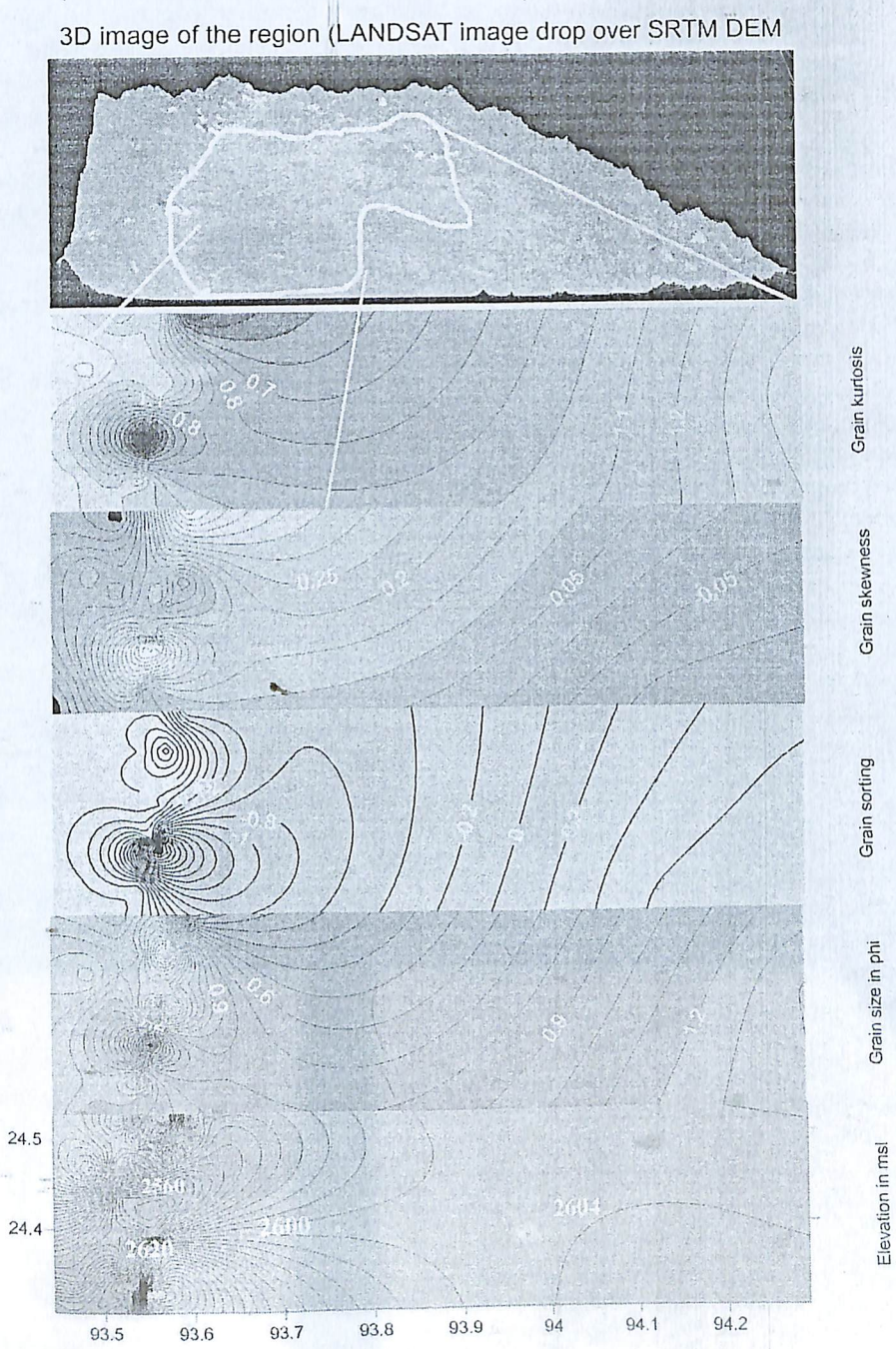

Fig. 3. Spatial variation of sedimentological charcaterstics of bed sediment in Imphal Valley.

variation. The coarse skewed nature is because of the selective removal of the fine sediments from the bed sediments in the eastern side.

The kurtosis plot shows that the sediments in the eastern side of the valley are highly leptokurtic, very platykurtic in the central part and in the southern part, the kurtosis increases with higher sorting of the finer sediments.

The spatial distribution characteristics of the sediments in the Imphal valley show that the size of the sediments is influenced by the local topography because of the prevailing low hydro-dynamic condition.

CONCLUSIONS

Sedimentological characteristics of the bed sediments in the Imphal valley indicate low energy condition of deposition of the same grain size in the beds of both the river and pond. The spatial variation of the sediment characteristic under low energy condition is controlled by the local topography. Long distance movement of the sediments derived under low energy condition is responsible for deposition of fine sediments in the downstream direction. This characteristic deposition resulted in development of marshy and wetland in the study area.

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