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Understanding the sediment sources from mineral composition at the lower reach of Rupnarayan River, West Bengal, India – XRD-based analysis

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ABSTRACT

Sources of sediments have been identified through study of mineral composition of sediments in the lower reach of the Rupnarayan River, West Bengal, India by X-ray diffraction (XRD) technique to understand the causes and mechanisms of sedimentation. Collected sediment samples are washed by hot and distilled water, dried and disaggregated manually with a mortar and pestle. Sediment samples are scanned at 7°–45°2θ interval by XPERT-PRO diffractometer. Diffractograms generated from XRD analysis reveals that the entire reach under study shows the dominance of minerals including quartz, illite, chlorite, chloritoid, anatase, goethite, oligoclase, sillimanite and corundum, having their origin in the upper and middle catchment with little contribution from lower catchment and river banks. Statistical test indicates that except tourmaline and anatase, all the minerals show steady trend in concentration in sediments. PCA reveals that five Eigen values account for 82.092% of the total variation of the distribution of minerals. There is no conspicuous trend in the spatial distribution of the minerals in the study area. The minerals drained from upper catchment are caught up in the estuary and again redistributed upstream by stronger flood tide. This leads to an unsystematic and irregular distribution of minerals in the study area.

1. Introduction

X-ray powder diffraction (XRD) is an instrumental analytical technique, which has been used to identify the mineral composition of unknown sediment samples for almost a century. Mineral composition of sediments supplemented by the textural characteristics provide insight into the source region and the depositional environment ([7,17] and [2]). Mineral deposition is influenced by differences in size, shape and density and reactivity. Peak intensity ratios of minerals in ponded sediment layers are diagnostic for different source areas and hydro-meteorological transport processes in catchment areas [19].

The lower reach of the Rupnarayan River, from Dainan to Geonkhali (40 km) (Fig. 1) has lost water storage capacity due to continuous sedimentation and development of shoal area. During the last 25 years the area has experienced a net sediment deposition of 26.57 million m^3 (estimated by Kolkata Port Trust, 1990–2015). The rate of sedimentation varies widely in different seasons at different places in the study area. The rate is high in dry season (pre-monsoon and post-monsoon) compared to monsoon season at all the places. Sedimentation rate varies between 2.22 mm/hr. to 3.54 mm/hr. in dry season and 1.29 mm/hr. to 2.98 mm/hr. in monsoon season [12]. Rapid sedimentation and development of shoal area creates a variety of detrimental problems and impacts on society, economies and the environment including the shifting of river course and thalweg position, shortage of water during neap tide for utilization in different purposes, hindrance of easy discharge of water and upstream flood, navigation difficulties, river bank erosion and loss of settlements and properties. In some places, the navigation problem is so acute that the vessels have to stay far away from the river bank and the people have to walk a long distance (more than 1 km) on the river bed to reach the river bank. Kolaghat Thermal Power Station, located on the right bank of this river is facing the problem of water shortage for power generation for last few years. In the month of March 2004 for about 2 days raw water feeding for power generation remained cut-off causing interruption in power generation. On 9th, 10th and 11th September of 2004, the reduction of water level during the neap tide was so alarming that it led to shut down the power generation of 3 units. Problems of sedimentation in this area were studied by Sinha and

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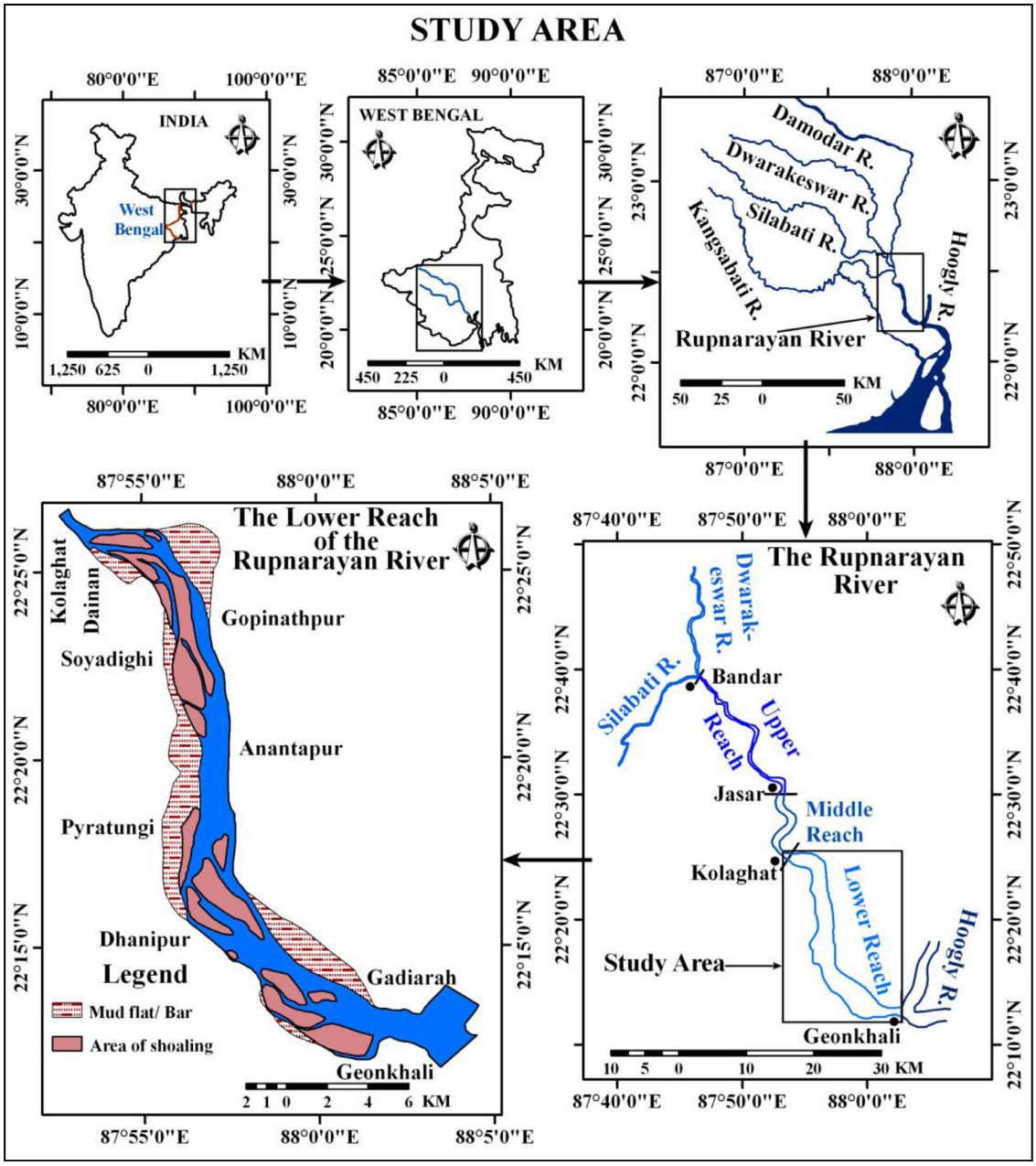

Fig. 1. The study area.

Basu [18] in a mathematical model using the Harmonic Method which provides insight into the tidal mechanism. The Calcutta Port Commissioners conducted the hydrodynamic survey at the lower reach of the river in 1968 to understand the sedimentation mechanisms. The Irrigation and Waterways Department of the government of West Bengal conducted the survey for the entire river in 1962–1963 and repeated the same for portions of the upper reach of the river in 1970 and constructed a mathematical model for the entire Rupnarayan River with the cross-sectional survey data. In the recent past an intensive survey was conducted jointly by Kolkata Port Trust and Kolaghat Thermal Power Project in this area. Identification of the sources of sediments is the key to understand the causes, mechanisms and dimension of sedimentation and becomes helpful to reduce the rate of sedimentation and the management of the associated problems in the area of interest. No such studies have been done in this location. This study offers the opportunity to understand the sources of sediments through identification of mineral composition of sediments in the concerned area to identify causes and mechanisms of sedimentation and formulating strategies for proper management of the associated problems.

2. Study area

The Rupnarayan River with its network of sub-tributaries including the Dwarakeswar, Silabati, Kangsabati and Damodar Rivers, is one of the main contributing tributary of the River Hoogly. River Silabati and Dwarakeswar meet at Bandar, and the combined flow is named as Rupnarayan, which joins River Hoogly at Geonkhali covering a distance of 78 km. The whole Trans- Damodar area drains through this river. The lower reach (study area) extends from Kolaghat to Geonkhali with a length of 40 km and is bounded by 22°12′N to 22°26′N and 87°53′E to 88°03′E (Fig. 1), approximately 10,930 km^2 catchment area of the Rupnarayan River. The study area has a typical tropical monsoonal type of climate with