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GRAVEL DEPOSITS OF DAUKI-PIYAIN RIVER BED AND SURROUNDING FLOOD PLAINS: A CASE STUDY

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Abstract

The Dauki-Piyain river is the major source of gravels in Jaflong area which is located on the alluvial plain south of the Khasi-Jainta Hills. Jaflong gravels comprise quartzite, granite, gneiss, amphibolite, basalt, sandstone and conglomerate. The gravels are mostly fresh and hard and can be used as good construction materials. The deposition of gravels is controlled by the frequency and intensity of water-flow in the Dauki-Piyain river forming the Jaflong quarry. The Dauki river is constantly changing its course. Controlling the river course and keeping its tract clear from debris will make the replenishment of the gravel deposit steady. The main economic activities of the local people are mostly dependent on the gravel and sand extraction business from Jaflong quarry. It is found that about 30,00,000 cubic meters of gravel from 200 hectares areas are extracted per year from the Dauki-Piyain river of Jaflong. The average revenue collected by the Government of the People's Republic of Bangladesh from this location stands at approximately 30.00 million taka per year.

Key words : Gravel deposits, Construction material, Flood plain, Sag pond, Extraction

Introduction

Location and geographical extent: The study area is located in the Goainghat upazilla, Sylhet District, Bangladesh. It lies in the south of the international border of India and extends North-East towards the Goainghat upazilla Headquarter (Fig.1).

Morphological features: The area lies in the floodplains of Dauki and Piyain rivers on the lowest part of the Tertiary hills (Fig.1). The southern and eastern parts the hills are mainly isolated, low in elevation (50 to 60 m) and dome shaped. In some parts tectonic sag-ponds are present. The piedmont slope and fans are highly dissected. The terraces of varying heights are common mainly along the fault alignment. Geomorphically the whole area is the foot-slope terrace and fan deposits built mostly by slope processes and fluvial activities.

Tectonic setup: The Eocene Hinge Zone separates the Bengal basin tectonically into two major subdivisions, viz., and Shelf area in the northwest and Geosynclinal area in the southeast. The surface and subsurface data indicate different stratigraphic history and structural features and events for these subdivisions. The study area lies in the geosynclinal part of the basin. This area is one of the most active tectonically controlled

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areas of Bangladesh which is characterized by subsidence resulting into tectonic sag ponds and depressions. This area is further separated from the Shillong Massif in the north by the Daulki Fault. The Shillong Massif is mostly igneous-metamorphic terrain which is the major source of the gravel deposits.

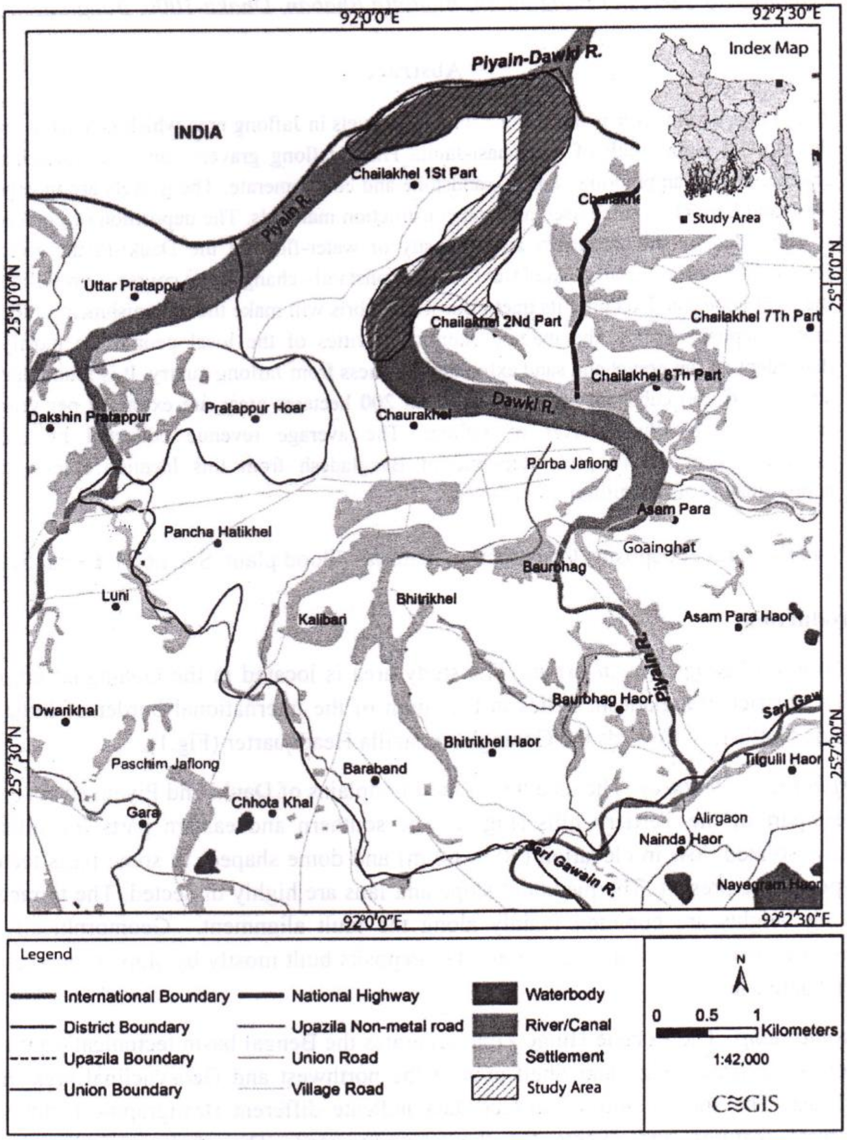

Fig. 1. Location and geomorphological map of the Dauki-Piyain river bed and surrounding floodplains (Map source CEGIS).

Purpose and scope: Bangladesh depends largely on the river borne gravels (Rahman and Manwar 1988) for construction and other purposes (Rahman 1987). In addition to the gravels of Patgram upazila, good quality building materials are present in limited quantities in the northern frontier regions of Sylhet and Mymensingh (Roy 1963). These stones are normally washed down from the Khashia and Jaintia Hills in India by the rivers during heavy rainfalls and floods (Hensen 1987) and consist mostly of granite, quartzite, gneiss and schist (Petrobangla 1977). The systematic quarrying of the gravel can be started only during the dry season when the rivers become shallow (Khan 1970).
In the present study an attempt has been made to investigate the geological, geomorphological and tectonic settings, extent and quarrying potentiality of gravel deposits and the impacts of gravel extraction on environment.

Materials and Methods

The current research approach is based on detailed and extensive field observation. The study area has been visited six times to collect the necessary data, such as rock type, quality of the rock types, extent of the area, to know the traditional extraction methods, etc. Most of the area is easily accessible and all the materials are exposed on the surface at river beds, bars, levee, and floodplain etc. depositional environments. There are dug pits at some places that offer very good sections up to the depth of 5 meters. The samples are easily available as hand specimens which have been identified by visual examination. The sediments consist of mostly pebble to boulder sized materials with easily identifiable mineral constituents. The sediment fragments can be easily measured using hand tape and scales. A geologic hammer is very useful to break the rock samples to observe the internal fresh mineral matters. Chemical method could not be applied because it was out of the scope of this study.

Geology: The study areas lie in the active river bed of Dauki-Piyain river. The surroundings are the Tertiary hills and the piedmont alluvial-colluvial plains of the Khasi-Jainta hills are completely sedimentary in origin (Hensen 1987 & Rahman and Manwar 1988). The gravels are dominantly non-sedimentary but they are transported, not in-situ products. The major geologic units of surrounding areas are Tertiary hills (Th), channel deposits (Cd), bar deposits (Bd), abandoned channel deposits (Acd) and flood plain (Fp) deposits (Fig. *2*). The tertiary sediments are mainly of Dupi Tila and Dihing Formations.

Mostly sands mixed with gravel and little silt dominates the surface lithology (Table 1). The tertiary sediments are compact and sandy. Layered gravels are available generally on the surface mixed with the coarse sand and are exposed in the foot-slope of the hills. The concentration of gravel and boulder increases with depth. The river bed sediments are dominated by the gravel and boulders with a very wide range of size distribution, with different composition and origin. The size of gravel ranges between 3 cm to 150 cm. This concentration is proven to depth till 20 meters in the upstream river bed. The gravel concentration is restricted and it faints out in the downstream area.

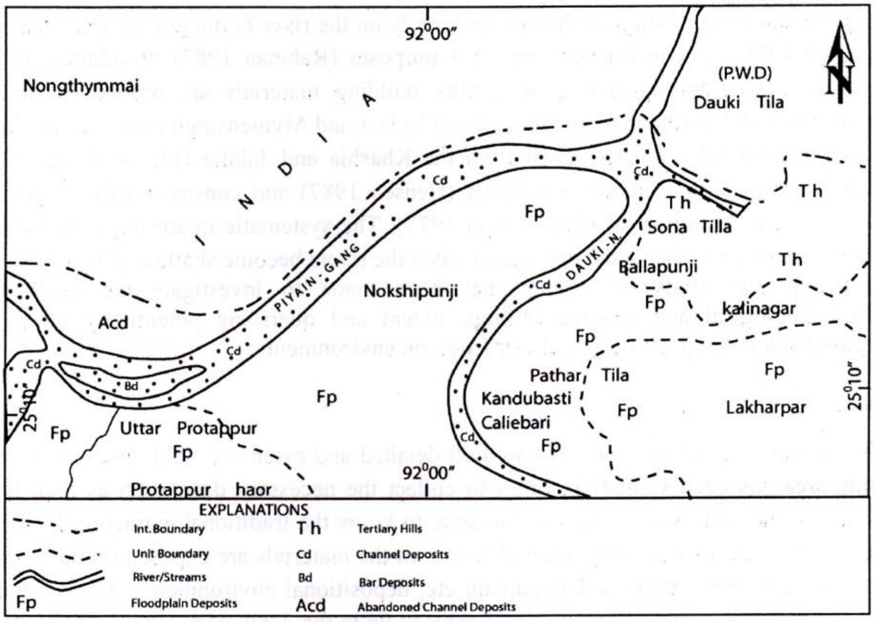

Fig. 2. Regional Geological Map of Dauki-Piyain river bed and surrounding floodplain (Topographic Sheet No. 78° /16, Scale 1:50000).

Table 1. The generalized sequence of the exposed sediments within the study area.

Formation	Lithology	Age	Thickness in Meters
Channel Deposits	Light brown to greyish brown, coarse to medium sand mixed with boulder, cobble and pebble. Gravels are mostly quartz, few rock fragments with some dark minerals.	Holocene	0.3 to 2^+
Bar Deposits	Light yellow to light brown, mostly coarse to medium grained sand and gravels. Dominantly quartz and few rock fragment.	Holocene	0.5 to 2.5^+
Flood Plain (levee and over bank) Deposits	Thick top soil cover, underlain by fine to medium grained sand with pebbles and cobbles, light yellow to light brown.	Holocene	1.5 to 5^+
Abandoned Channel Deposits	Thin top soil cover, underlain by coarse to medium grained sand with pebbles and cobbles, light yellow to light brown.	Holocene	1 to 3^+

Results and Discussion

Earlier more or less similar work was carried out in Bholaganj areas by Rahman and Manwar (1988) but no such work was done in the study area. The current study focuses on the active and depositional processes, economic values, quality and suitability, reserve, natural hazard potential, hazard mitigation, environmental aspects and socio-economic aspects.

Active processes: The main active geomorphic processes of this area are high-flow regime super critical stream flow, flash flood and deposition of gravel and sand from the upper catchments area during the monsoon. Along the river bed and the valley-slope huge volume of gravel and sand are transported by the river during flash flood. The bank erosion and shifting of river thalweg is a common phenomenon. The super critical flash-flood flow in monsoon is one of the major natural hazards in this area. The annual flood level is 1.00 meter above present landform for 1.5 months in the flood plain area. The duration of flash flood is highly unpredictable.

In general this area lies in the most susceptible zone for earthquake and flash flood hazards. The zone is the most tectonically active area of Bangladesh. The river Dauki and Piyain are flowing along an active fault line and this area is the part of an active subsiding zone (Bilham and England 2001). Bank erosion and unstable slopes are the other major hazardous phenomenon in this area.

Depositional processes: The boulders and gravel are transported from different bed rocks eroded by the stream from the upper catchment areas during the monsoon. The rainfall rate of the upper catchment areas is very high, one of the highest in the world. The high energy and high gradient water flow erode the bed rock in the upper-catchment areas and transport the boulder, gravel and sand to the down slope areas. Across the Dauki fault the flow energy drops suddenly when it travels through plain land. The river velocity drops, as well as the transportation energy and flashes most of the coarser sediments at the mouth of the river where plain land starts. Also huge volume of gravel and sand were deposited as colluvial fan and foot-slope deposits due to high slope-gradient along the slopes.

In the river bed and in the valley-floor huge volume of boulders, gravel and sand accumulate during the flash flood. The same phenomenon occurred along the foot-slopes of the hills. With the gravity and fluvial activities the boulders and gravel were being transported from upper-catchments areas and deposited on the flat flood plains in the high-flow period. These sediments gradually get a cover of finer sediments on top during the dry or low-velocity flow regime. This depositional process is a continuous dynamic natural process.

Economic deposits: The main economic deposits in the study area is the river bed gravel, sand and the sub-surface gravel deposits in fluvial-colluvial fan and terrace areas. It begins to occur on the river bed at depths ranging from bed surface to more than 5.00 meters. The top 0.2 meter is mainly sandy and finer rock fragment cover. Below that layer very coarse sand mixed with gravel by 15-20% are common. The size of the coarser part increases with depth and the sand percentage is reduced. The active channel beds can be excavated in the dry season when the channels are in low-flow condition. The gravel deposited on the river bed can be excavated even in high-flow regime, if the water depth remains shallow.

The actual thickness of the gravel deposits is not precisely determined throughout the area, because of variable layer thickness. Data from open pit logs along with few natural exposures in the area and local people information, it has been inferred that the general thickness of the gravel ranges between 5 meters and 15 meters; the base of the layer has not been penetrated.

Quality and suitability: Mostly the gravel is made of quartzite, granites, gneiss and basalt with few sandstone and conglomerates. They are commonly fresh but about 10-15% are weathered of different degrees. This varnish is generally on the surface and does not affect their strength in most of the cases. Quartzite gravel are white, pink grey, or smoky in color. They are about 40% of the total gravel deposits. Granites come in second with about 30% of the deposits, they are mostly course-grained pink granite. The remaining parts of the deposits comprise of gneiss, basalt, sandstone and conglomerates, which are in wide variety in color.

The gravel is very hard and hence can be used as construction aggregates and blocks. They are mostly used as bed material in the construction of roads and railroads and for the concrete in civil construction. The basalt is used in the mosaic industry as chip material (black stone). Shaping the big blocks of pink granite could be used as floor and wall tiles. The smaller size pebbles and cobbles are used in general construction.

Reserve: The estimation of the reserve of gravel is based on the horizontal and vertical extent of the deposits. It has been expected that, it is uniform horizontally but thickness may change in vertical direction. The depth of gravel beds also varies place to place. In the river bed the gravels get usual replenishment by the high-velocity river-flow in every monsoon. Surface quarrying on the river bed is possible every year. It is possible to excavate the gravel for 6-7 months, but it has to be dug out from increasingly greater depth incurring increasing cost.

The total study area is about 200 hectares, extractable thickness of the gravel is 5.0 meters per year and gravel concentration is about 30% of the total deposit. Then the total reserve can be estimated which equals about 200 X 10000 X 5.0 X 30% = 30,00,000 cubic meters. The active channel bed gets the usual replenishment of gravel by the river every monsoon, so the volume of the gravel will be an addition to the total reserve. The volume and quality of annual replenish gravel is highly unpredictable, because of wide variety of factors controlling the flow-regime.

Natural hazard potential: The study area is susceptible to different types and degrees of hazard.

Nature and types of hazard: The major types of natural hazard potential in this area are listed below:

- Tectonic and earthquake hazard- the highest degree in the area
- Flash Flood- most vulnerable area during the monsoon time
- Subsidence- possibilities only due to tectonic reason.

Hazard mitigation: Major and minor earthquakes are the most common natural phenomenon in this area (Bilham and England 2001). For the purpose of mitigating this hazard it is wise to construct the earthquake resistant civil structures with proper engineering measures.

Due to geomorphic setting of this area, the flash flood susceptibility is very high, which can not be ignored in development planning. To reduce the loss due to this hazard it is essential to identify the main flood route and leave that space clean removing all the anthropogenic obstacles. Combination of structural and non-structural method could be adopted to mitigate this hazard. Small dyke, bank protection measures and locating the civil structures in less vulnerable area, the damage of this hazard could be mitigated.

Environmental aspects: Most of the study area is 'Khas' land and lies in the active river channel of the Dauki-Piyain river. In this area, the extraction process is carried out from the stream bed, where no habitation and agricultural land exist. There is no chance of chemical pollution due to these quarry activities in this area. From this activity there are no threat to the aquatic life and the general environmental balance of this area. The area is located far from any large civil structure. So, the quarrying activity will not affect the foundation of any civil-structure. The excavation from the river bed will increase the base level of the river bed, of which the water holding capacity of the river increases and the thalweg of the river remains stable. This activity acts as free-of-cost river dredging and helps to reduce the river bank erosion.

Socio-economic aspects: The socio-economic condition of this area is mainly agriculture and quarrying activity based. During the extraction of gravel, a major part of the local population is being employed, either to extract it or to transport it and in various related activities. The females of the area can also be engaged in lighter activities, such as sorting and stacking of the gravel. This helps to alleviate their poverty level providing the job opportunity and plays positive effect on socio-economic condition boosting the local economy. The local communication system is also improved by the local people-effort during the extraction process.

Extraction of locally available minerals helps to create an economic boom to the area and to achieve the poverty alleviation program of the government. The government also earns the additional revenue from this resource in a defined accounts head, which could contribute an important role in our national building development budget.

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