

Chapter 2

Hydro-Geomorphology

Abstract The geomorphology plays an important role in the extent and nature of the shallow aquifer system. Satellite maps have been interpreted in terms of hydro-geomorphology. Upper deltaic plain, lower deltaic plain, older coastal plain and younger coastal plain are the different geomorphic belts in the area. Various landforms such as beach ridges, swales, beach ridges and swale complexes, beaches, palaeo beach ridges, palaeo beach ridge & swale complexes, back swamps, buried channels, palaeo-channels, channel islands, migrated river courses, channel bars and natural levees are found within these geomorphic belts of the study area. The shallow freshwater is found in the beach ridges, palaeo beach ridges, channel bars, migrated river courses and natural levee having good yield potential. Some amount of fresh water is also expected from palaeo channels and buried channels.

Keywords Geomorphology • Deltaic plain • Freshwater • Beach ridges • Palaeo channel • Natural levee • Channel bar • Swale

2.1 Introduction

The geomorphology plays an important role in the nature and extent of the shallow aquifer system in the study area. The physical features of different structures also control the ingress of salinity in different part. Geological Survey of India, Directorate of Geology (Odisha), National Remote Sensing Agency and various workers (Sambasiva Rao et al. 1978; Vaidyanadhan 1987, 1990; Mahalik 1984; Meijerink 1983; Samal and Das 1989; Kumar and Bhattacharya 2003; Mahalik et al. 1996) have carried out geomorphological studies in the Mahanadi delta. The geomorphological data and maps were collected from various agencies and compiled. Satellite maps of the study area were interpreted in terms of hydro-geomorphology (Fig. 2.1) and ground surveys were conducted by way of field traverses using global positioning system (GPS) to cover different geomorphic

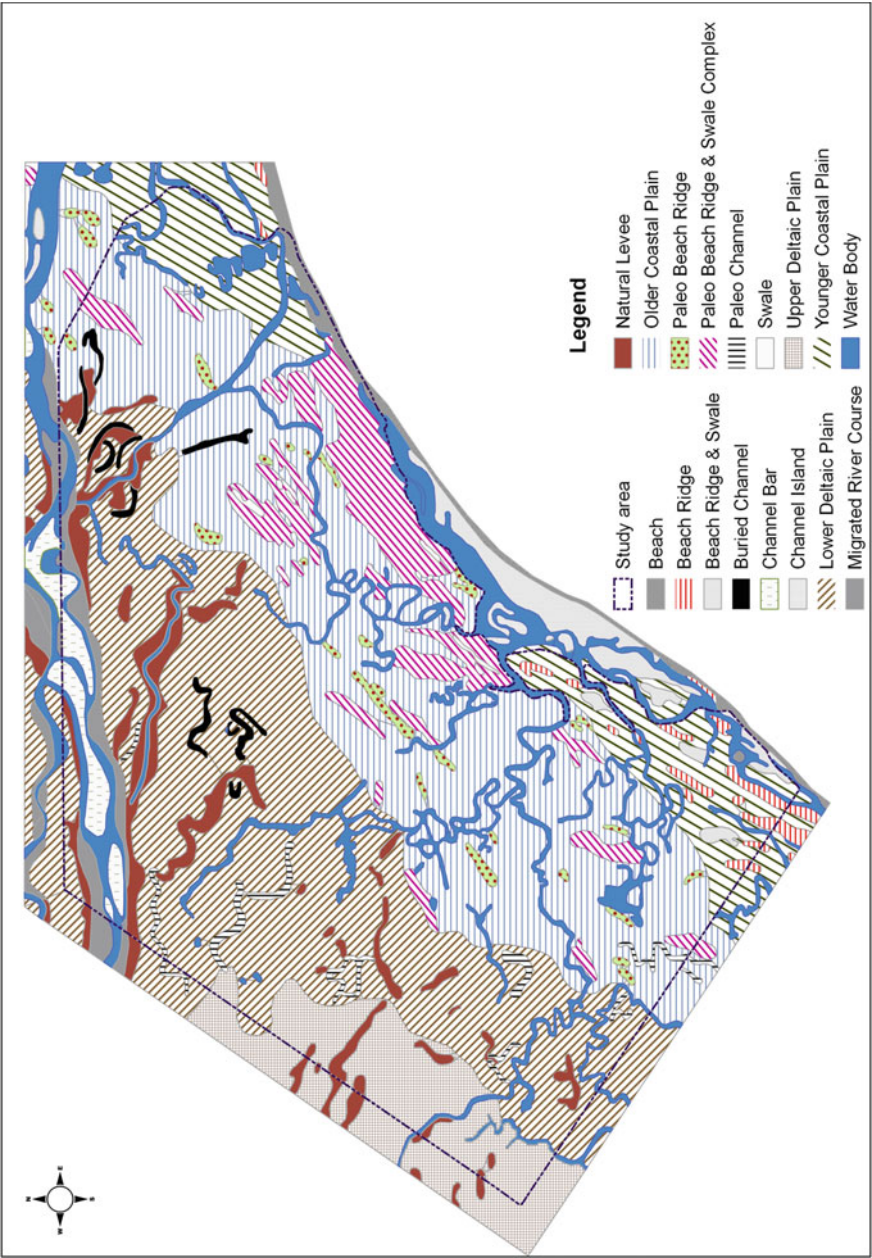


Fig. 2.1 Hydro-geomorphological map of the study area

units/landforms. The different hydro-geomorphic units and landforms were correlated with the geophysical studies, water quality and other hydrogeological character of the shallow aquifers. The nature and extent of the deep aquifers are dealt separately.

2.2 Geomorphic Regions

The study area can be broadly divided into two major geomorphic regions, the deltaic plain and the coastal plain. Depending on the agents responsible for the formations, presence of different geomorphic features and age of formation, the deltaic plain has been divided into lower and upper deltaic plains. Similarly, basing on age/time of deposition the coastal plain has been divided into younger coastal plains and older coastal plains. The different regions have different hydrogeological characters.

2.2.1 Upper and Lower Deltaic Plains

The upper portion of the delta sequence is the delta plain, which is a combination of distributary channels and inter-channel environments. These are flat to gentle sloping plains of large aerial extent with thick sediments exhibiting a fan shape formed at the end of river cycle. The delta plain is further classified into two areas: the upper delta plain and the lower delta plain. Although these two areas are comprised of different components, both are dominated by fluvial processes. The upper delta plain is located above the high-tide sea level and therefore, has no marine interaction. Therefore, this plain consists of material from river borne sediments mostly alluvium.

The upper deltaic plain is found in the southwestern part of the study area. Mostly the natural levees are the only geomorphic features found within this region. Here the yield potential of groundwater is good, but the salinity is the main cause of concern.

The lower deltaic plains (Fig. 2.2) are found in the western part of the study area after the upper deltaic plain. Natural levees, palaeo-channels and buried channels are the different geomorphic features noticed within this region. Here, the groundwater yield prospect is very good, but the salinity remains as the main cause of concern. The water levels in this region of the study area were between 2.0 mbgl (meters below ground level) and 3.4 mbgl during pre-monsoon 2007.

Fig. 2.2 View of lower deltaic plain near Asarana



Fig. 2.3 Older coastal plain near Rajpur



Fig. 2.4 Younger coastal plain near Chanakana



2.2.2 Older and Younger Coastal Plains

This is the regional land of low relief bounded in the seaward side by the shoreline and landward by highlands mainly formed by coastal action. The younger and older refers to respective age/time of formation. The younger coastal plain lies close to the sea and different marine agents are active here. The older plain lies slightly away from the sea and are bounded by the younger coastal plain in the seaside (Figs. 2.3 and 2.4).

Geomorphic features like beaches, beach ridges and swales are conspicuously found within the younger region, whereas palaeo-beach ridges and palaeo-swales are common in the older coastal plain. The younger plain contains more dead shell pieces than the older plain. Here the yield of groundwater is good, but salinity is the main problem except in beach ridges. The eastern and southeast part of the study area comes under this region. The water level in this region was between 1.4 and 2.8 mbgl during pre-monsoon 2007.

2.3 Geomorphic Landforms

Different geomorphic landforms formed by fluvial and marine processes are found within different geomorphic zones. Each geomorphic feature has got distinct hydrogeological characters. A brief description of different landforms of the study area is given below.

2.3.1 Beach

A beach is a geological landform along the shoreline. Beaches often occur along coastal areas, where wave or current action deposits and reworks sediments. It usually consists of loose particles, which are often composed of rock fragments, such as sand, gravel, pebbles, etc. Besides, the beach sediments sometimes contain shell and coralline algae fragments of biological origin. Hydrogeologically, salinity is the main problem in the groundwater of the beach region. Freshwater occurs at shallow depth maximum up to 10 m and floats over the saline water, giving the typical Ghyben-Herzberg relationship (Fig. 4.1).

2.3.2 Beach Ridges

These are the landforms of marine origin. A beach ridge is a wave-swept or wave-deposited ridge running parallel to shoreline. It is commonly composed of sand as well as sediments derived from underlying beach material. A beach ridge

Fig. 2.5 Beach ridge at Sarabanta



Fig. 2.6 Palaeo beach ridge at Rajpur



may be capped by, or associated with, sand dunes. The height of a beach ridge is affected by wave size and associated energy (Figs. 2.5 and 2.6).

These are the most common features of the younger coastal plain, where fresh groundwater is available at a shallow depth. Here the groundwater prospect is excellent. Due to easy availability of drinking water and being the local uplands, these ridges are thickly populated. Large number of domestic dug-wells and shallow tube wells are found on these features. The water level of the phreatic aquifer on this ridge at Sarabanta was 2.99 m during pre-monsoon 2007. Geophysical log at Nuagaon (Fig. 3.9) also shows the shallow fresh water bearing aquifer in the beach ridge. The palaeo-beach ridges are older beach ridges found within the older coastal plain and have similar hydrogeologic characteristics.

2.3.3 Swale

Swales are the landforms formed by the marine processes and found in the older and younger coastal plains of the study area. These are linear depressions formed in the ground to receive runoff and slowly move water to a discharge point. It holds water and allows it to gradually infiltrate into the soil along the slope. Soil and water run-offs are caught in the swale, which becomes a fertile area. Gradual infiltration of water, nutrients and the dead roots of plants growing in the swale, slowly improve soil structure down-slope.

Lithologically, swales are characterized by alternate layers of sand, silt and clay. Groundwater in this zone is generally brackish in nature and due to the fineness of sediments the yield potential is also not good.

2.3.4 Beach Ridges and Swales Complex

These are the complex areas with integrated beach ridges and swales and are the dominating landforms in the younger coastal plains. These complexes are characterized by alluvium with dominance of sand and silt. Here, freshwater occurs at shallow depth over brackish water in the beach ridges. The palaeo beach ridges and swale complexes are the older landforms mostly found within the older coastal plain and have similar hydrological characters.

2.3.5 Palaeo-Channel

These are old narrow arcuate tract within alluvial plain and comprise of fluvial deposits of varying grain-size and lithology. In the study area, few palaeo-channels are found mostly in the lower deltaic plain (Fig. 2.7). These are promising zones for groundwater exploitation but may be contaminated with saline water in many places.

2.3.6 Buried Channel

These are the old channels buried under shallow sediment cover. In the study area, a few buried channels have been identified. Groundwater potential of this landform is very good but salinity is the main cause of concern except where these channels have recharge source from the main distributaries.

Fig. 2.7 Palaeo channel near Pankapal



2.3.7 Back Swamp

Back swamps and Backwater Lake form when water fills natural hollows on the landside of a natural levee. The levee prevents the floodwater from flowing back into the river and also traps water from the tributary systems. Back swamps and backwater lakes occur in low-lying areas on the landside of a natural levee. A very small patch of this landform is present in the central part of the study area. No shallow freshwater is available here.

2.3.8 Channel Bar

These are small alluvial patches forming part of the riverbed. These bars receive very good recharge from the river and the groundwater is expected to be fresh. It is

Fig. 2.8 Mahanadi flood plain near Bhutamundai



found within the Paika Nadi and the river Mahanadi in the northern part of the study area. These are potential zones for groundwater exploitation.

2.3.9 Channel Island

These are the small islands within the rivers and are made up of mainly sand and silt. Freshwater may be found as thin capping at very shallow depth. These landforms covering a very small part of the study area are found close to the sea. The groundwater in these regions is often contaminated with saline water.

2.3.10 Migrated River Course

These features are found mostly in the northern part of the study area and close to Paika Nadi and Mahanadi River. These courses get very good recharge from the river flow and are very good zones for groundwater exploitation. The shallow groundwater is found to be fresh and potable.

2.3.11 Natural Levee

The ability of a river to carry sediments varies with its velocity. When a river floods over its banks (Fig. 2.8), the water spreads out and deposits its load of sediment. Gradually, the river's banks are built up above the level of the rest of the floodplain. The resulting ridges are called natural levees. Natural levees are common features of all the meandering rivers.

Fig. 2.9 Natural levee near Hansura



In the study area, numbers of natural levees are found in the deltaic plains. One such levee near Hansura, in the northern part of the study area is shown in Fig. 2.9. Lithologically, levees consist of mostly sand and silt and are good sources of potable groundwater. The geophysical log at Hansura also shows the presence of shallow fresh water aquifer (Fig. 3.7).

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