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An appraisal of geohydrological characteristics of Puri Sadar Block, Orissa, India

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ABSTRACT

The coastal wetlands are facing a great danger because of rapid and significant changes in the coastal system, especially in the near-shore areas. The present paper deals with the aquifer characteristics of the Puri Sadar Block (19°45': 19°55' N and 85°45': 86°00' E) by geophysical and geochemical methods. The average value of total dissolved solids (TDS) is 840 ppm and the cation and anion contents range from 0.1 to 10 mg/l, and from 7.8 to 5,400 mg/l, respectively. The maximum thickness of fresh aquifer is 30 m.

INTRODUCTION

Groundwater is the most important, largest, and cheapest source of drinking water. Hence, it is an urgent need to ascertain the process that controls the quality, quantity, and flow of groundwater. Due to complex activities, coastal wetlands in general are facing a great danger because of the rapid and significant changes in the coastal system, especially in the near-shore areas. The State of Orissa, lying along the eastern coast of India, is economically backward but has high potential of natural resources. In this area, groundwater development is nominal owing to such factors as traditional cropping pattern, lack of sophisticated technological infrastructure, and disconnected and small land holdings.

It is necessary to carry out hydrogeological exploration and development in coastal areas to delineate saline-freshwater interface and to calculate the annual outflow of subsurface freshwater to the sea. Das (1991), Kaila et al. (1987), Mahalik (1991), and Das et al. (1998) have studied various aspects of groundwater in Orissa. The present paper deals with the hydrogeological characteristics of the Puri Sadar Block, which lies between latitudes 19° 45' and 19° 55' N, and longitudes 85° 45' and 86° 00' E along the eastern coast of India (Fig. 1).

GEOLOGICAL SET-UP

Hydrological investigation was carried out in an area of 50 sq. km to delineate the freshwater and saline water zones. The area belongs to the greater Mahanadi delta system, which is basically a flat terrain with a maximum elevation of 6 m above mean sea level. The area remains waterlogged for a period of 2–6 months in a year. The rivers Bhargavi and Nuanai control the main drainage systems. The area is underlain by the Newer Alluvium on which the local farmers mainly depend for cultivating *kharif* crops with an average rainfall of 1449 mm.

The sandstones and shales of the Gondwana Group are encountered only in the boreholes. The Tertiary deposits are found up to a depth of 120 m below ground level, which include mainly marine fossiliferous deposits of brown and yellowish grey clay.

The Quaternary deposits have laterites with an average thickness of about 9 m. The Older Alluvium includes a sequence of sand and clay whereas the Younger Alluvium covers nearly 90% of the area with an admixture of silt and sand with the thickness increasing towards the sea. The depositional environments have been identified as fluvial, estuarine, and marine (Mahalik 1995). There has been intermixing of environmental conditions because of alternating marine transgressions and regressions.

HYDROGEOLOGY

The quality and potentiality of groundwater is controlled by the geomorphic changes, environment of deposition, and the degree of subsequent recharge. The unconsolidated and porous Tertiary and Quaternary sediments are the main repositories of groundwater. The shallow aquifers occur under phreatic conditions, which prevail up to a depth of 135 m below land surface. The deeper aquifers occur under semi-confined to confined conditions. The aquifers are extensive and interconnected with their thickness varying from 6 to 79 m. The common groundwater abstraction structures are dug wells, shallow and deep tube wells, and filter points.

A systematic resistivity survey was conducted to study groundwater movement of the shallow aquifer. Based on the well inventory data, depth to water table for pre- and post-monsoon was obtained, which had a value within 1 m below the surface. The waterlogged area shrinks from 112.18 sq. km in November to 58.09 sq. km in January, and further to 4.80 sq. km in summer (May). The following resistivity values of the aquifer materials are derived from the field data of Vertical Electrical Sounding (Fig. 2).

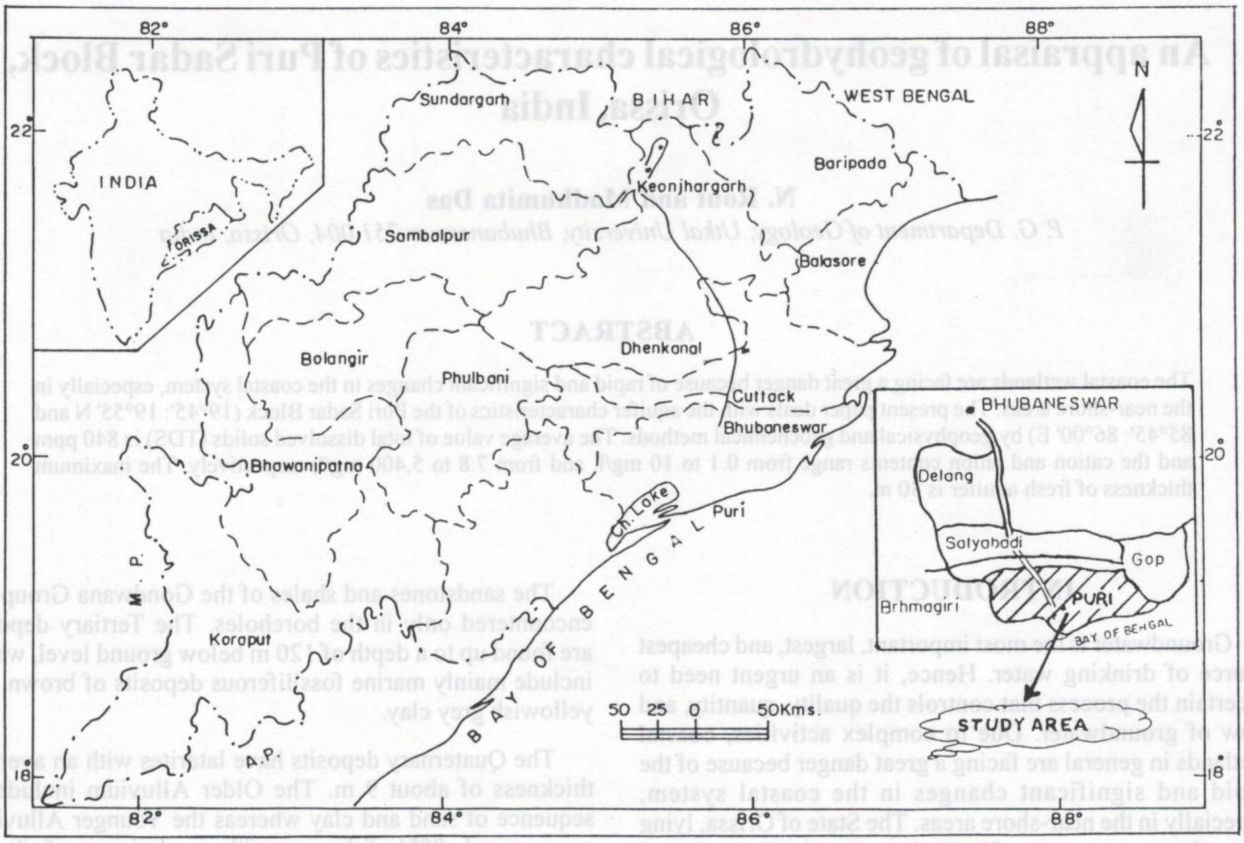

Fig. 1: Location map of Orissa

Resistivity (Ω.m)	Lithology
1 – 3	Sand saturated with saline water
3 – 5	Clay
5 – 15	Clay sand saturated with brackish water or lay saturated with freshwater
>15	Granular zones with freshwater

The groundwater resource estimated by Central Groundwater Board is as follows:

Total Groundwater resource	– 5815.03x10⁴m³
Utilisable groundwater for irrigation purpose	– 4942.78 x10⁴ m³
Groundwater for drinking purpose	– 872.285 x10⁴m³
Gross annual draft	– 1244.66 x10⁴ m³

The utilisable irrigation potential (in terms of area) of the district was estimated considering 90% of the available groundwater resources for irrigation (4942.78 x10⁴ m³) leaving the rest 10% to avoid adverse effect on the groundwater regime resulting environmental hazards.

HYDROGEOCHEMISTRY

The quality of groundwater from phreatic zone was studied to assess its suitability for domestic and irrigation utility. The average value of the chemical analysis is given below.

Chemical analysis of groundwater, Puri Sadar Block

Temperature (°C)		27.5
pH		8.21
Specific conductance (µS/cm at 25° C)		1425
Total dissolved solids (TDS) in mg/C	-	840
Calcium (mg/l)	-	122
Magnesium (mg/l)	-	18
Sodium (mg/l)	-	110
Potassium (mg/l)	-	70
Bicarbonate (mg/l)	-	488
Chloride (mg/l)	-	184
Nitrate (mg/l)	-	15
Sulphate (mg/l)	-	46
Fluoride (mg/l)	-	69
Iron (mg/l)	-	02

The groundwater is alkaline in nature and suitable for drinking purposes except in local pockets. According to the

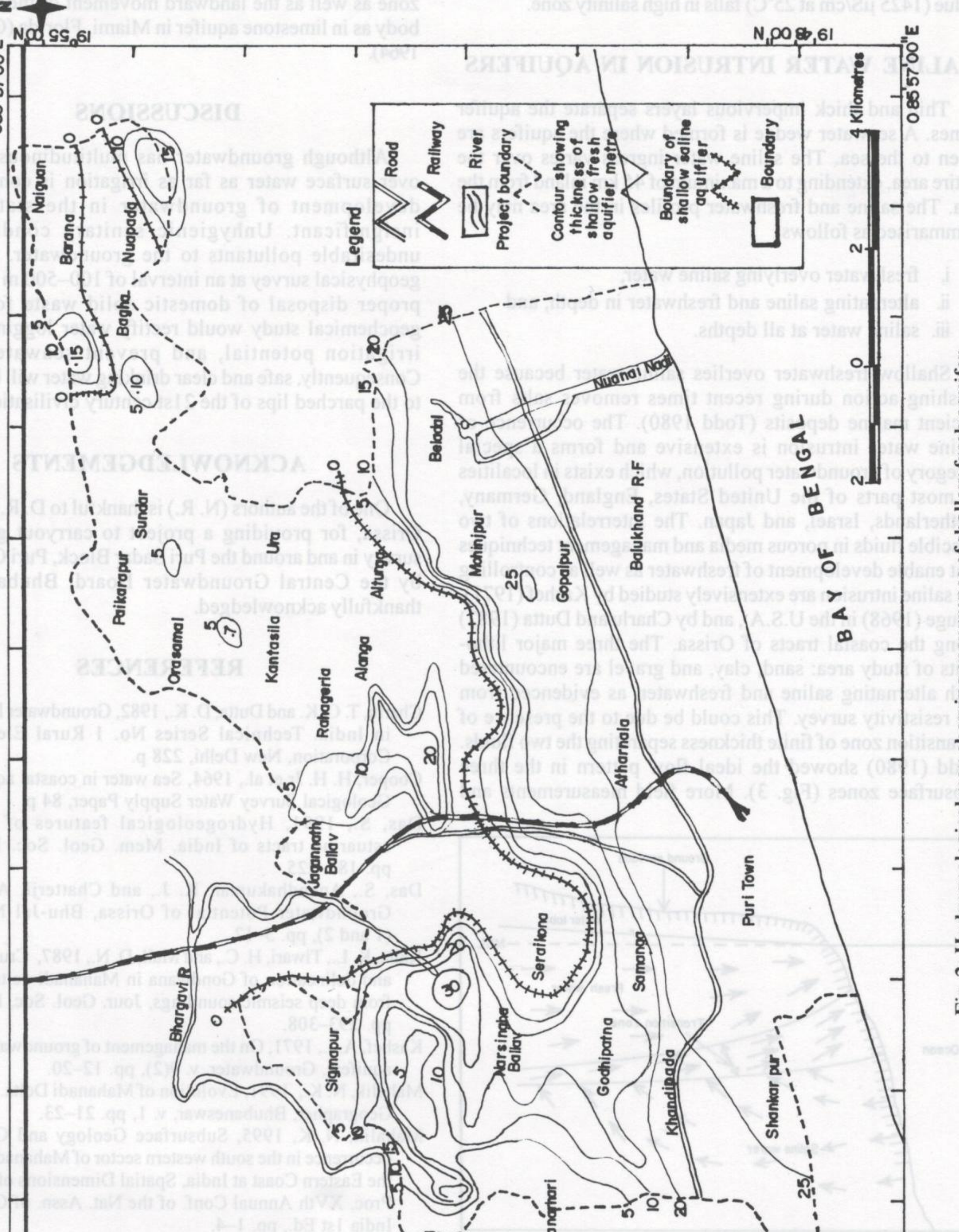

Fig. 2: Hydrogeological map showing occurrence of shallow fresh aquifer

U.S. salinity laboratory classification, the specific conductance value (1425 μS/cm at 25°C) falls in high salinity zone.

SALINE WATER INTRUSION IN AQUIFERS

Thin and thick impervious layers separate the aquifer zones. A seawater wedge is formed where the aquifers are open to the sea. The saline water ingress varies over the entire area, extending to a maximum of 45 km inland from the sea. The saline and freshwater profiles in the area may be summarised as follows:

i. freshwater overlying saline water,
ii. alternating saline and freshwater in depth, and
iii. saline water at all depths.

Shallow freshwater overlies saline water because the flushing action during recent times removes salts from ancient marine deposits (Todd 1980). The occurrence of saline water intrusion is extensive and forms a special category of groundwater pollution, which exists in localities of most parts of the United States, England, Germany, Netherlands, Israel, and Japan. The interrelations of two miscible fluids in porous media and management techniques that enable development of freshwater as well as controlling the saline intrusion are extensively studied by Kashef (1971), Rouge (1968) in the U.S.A., and by Charlu and Dutta (1982) along the coastal tracts of Orissa. The three major litho-units of study area: sand, clay, and gravel are encountered with alternating saline and freshwater, as evidenced from the resistivity survey. This could be due to the presence of a transition zone of finite thickness separating the two fluids. Todd (1980) showed the ideal flow pattern in the three subsurface zones (Fig. 3). More field measurements and experimental studies are needed to confirm the transition zone as well as the landward movement of the saline water body as in limestone aquifer in Miami, Florida (Cooper et al. 1964).

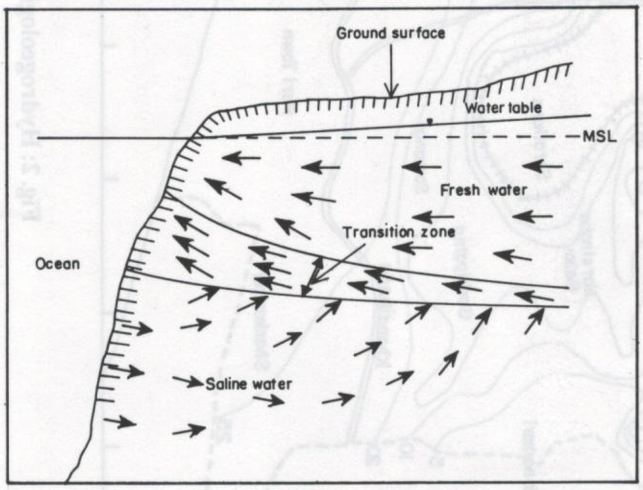

Fig. 3: Vertical cross-section showing flow patterns of fresh and saline water in an unconfined coastal aquifer (after Todd 1980)

DISCUSSIONS

Although groundwater has multitudinous advantage over surface water as far as irrigation is concerned, the development of groundwater in the state remains insignificant. Unhygienic sanitary condition adds undesirable pollutants to the groundwater. Systematic geophysical survey at an interval of 100–500 m grid points, proper disposal of domestic solid waste followed by geochemical study would rectify water logging, increase irrigation potential, and prevent seawater ingress. Consequently, safe and clear drinking water will be available to the parched lips of the 21st century civilisation.

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