

# Environmental isotopes to test hypotheses for fluid mud (mud bank) generation mechanisms along the southwest coast of India



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## ABSTRACT

Occurrence of fluid mud (mud banks) in the southwest coast of India is an enigma for the scientific community. Over the years, several multi-disciplinary studies were conducted and various hypotheses were postulated on the occurrence and sustenance of fluid mud. Nevertheless, none of them could be proved or disproved with field data. In the present study, an attempt was made to assess the validity of some of the prevailing hypothesis on its occurrence such as subterranean conduit flow of mud/water from a coastal lagoon, submarine groundwater discharge, river flows etc. by integrating field surveys, refining the hydrogeological understanding of the area and application of environmental isotopes ( $^{222}\text{Rn}$ ,  $\delta^{18}\text{O}$ ,  $\delta^2\text{H}$  and  $^3\text{H}$ ) in the 'Alappuzha mud bank' region, Kerala, during its formation in the southwest monsoon period. In-situ  $^{222}\text{Rn}$  monitoring survey in the coastal waters of Pallana showed that  $^{222}\text{Rn}$  activities in the fluid mud region were negligible compared to the suspected continental end members such as Pamba River, Vembanad Lagoon, shallow and deep groundwater indicating that there was no freshwater inputs from these sources. Comparison of the characteristic stable isotopic signatures of  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  in the samples from the fluid mud region and the suspected continental end members implied that there was no mixing of these water sources with the seawater.  $^3\text{H}$  results indicated that the shallow groundwater is modern and recharged annually from precipitation while deep groundwater in the Warkali aquifer within the study area is old (>50 years). It also indicated that there is no vertical interconnection between the Vembanad Lagoon and the deep Warkali aquifers. Hence, from the study, it appears that river flows, submarine groundwater discharge or subterranean (conduit flow) flow from the Vembanad Lagoon may not be responsible for the occurrence and sustenance of fluid mud in Pallana coast, Alappuzha.

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## 1. Introduction

Mud banks are calm, turbid waters having high loads of suspended sediments (more than 1500 mg/l) occurring in the coastal regions during monsoon season. Although mud banks are known to occur along the southwest coast of India for at least three centuries, the cause of their occurrence is still an enigma for the local and the scientific community. Mud banks do occur in other continental shelves as well, such as along the Guiana coast (Froidefond et al., 1988; Lentz, 1995), shallow inner shelves of Surinam (Wells and Coleman, 1981; Rine and Ginsburg, 1985); Florida, Louisiana (Wells and Roberts, 1980), Gulf of Papua (Wolanski and Alongi,

1995), northeastern coast of Africa, Gulf of Thailand, Gulf of Po Hai, where and the source and transport mechanisms of mud are, to some extent, reasonably understood. In these regions, the mud generally originates from the watersheds through river mouths or estuaries, transported along shore and deposited to form banks due to stratification in coastal waters because of freshwater discharge (e.g. Allison et al., 2000). The mud banks in the southwest coast of India are quite unique because of their peculiar characteristics, transient nature, extremely unpredictable periodicity, improbable location of appearances and occurrence away from river mouths. Frequently, they occur in Alappuzha, Kochi and Kozhikode coasts in Kerala, south India (Fig. 1). Since they do not form any topographic reliefs such as sediment banks, Mallik et al. (1988) proposed an appropriate terminology for these mud banks as 'fluid mud'. Henceforth, the term – fluid mud is used throughout this paper rather than mud banks.

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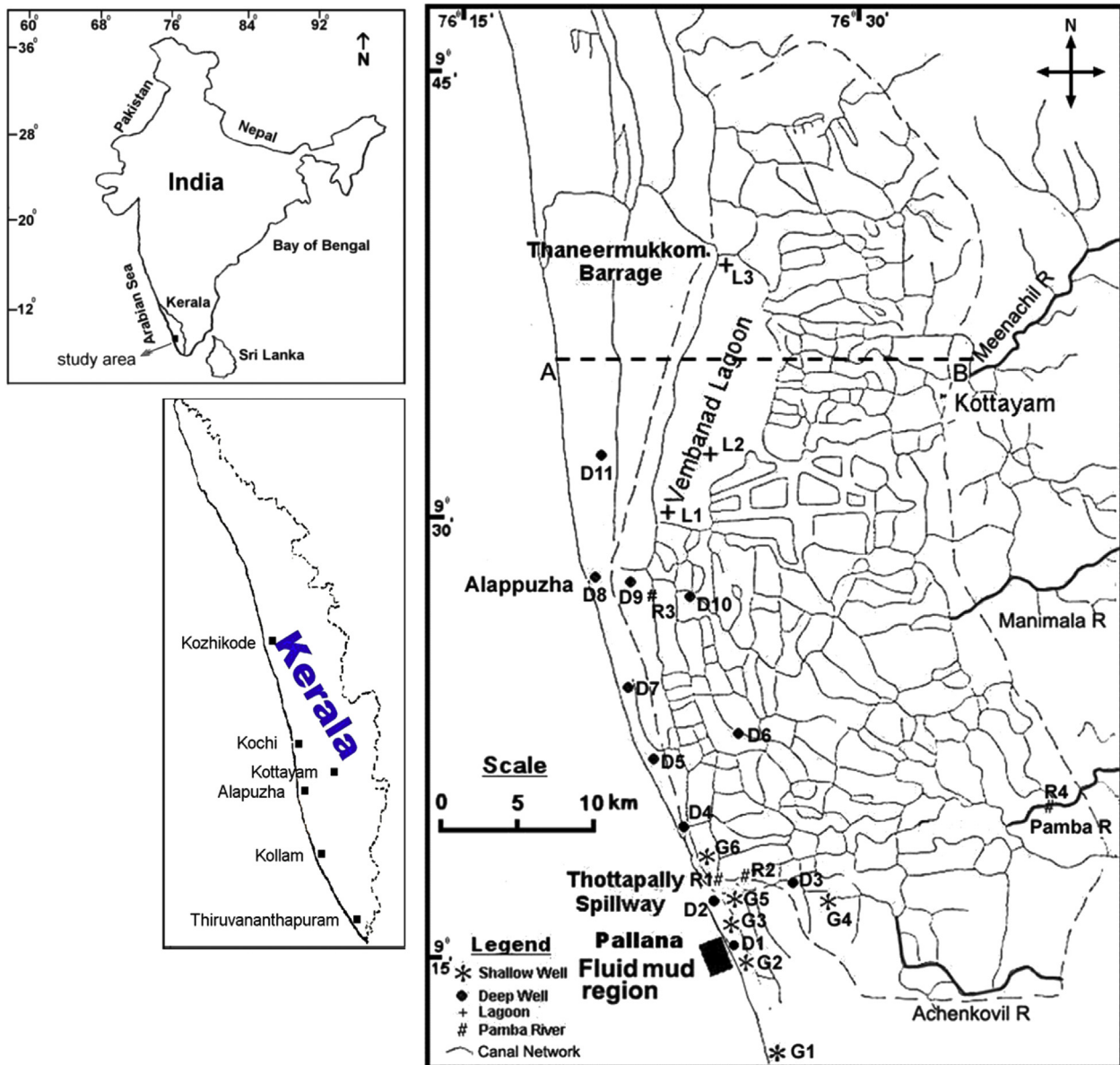


Fig. 1. Location map of the study area showing the sampling points.

Fluid mud usually forms near the Kerala coast in a semi-circular shape with average distances of 4–5 km along shore and 5–6 km offshore, respectively. It is characterized by a heavy suspension of dark, grayish – green fine clay of less than 10  $\mu\text{m}$  diameter at sea surface and a highly viscous unconsolidated liquid mud at the bottom with a wedge-shaped geometry thinning towards the sea (Mallik et al., 1988). Fluid mud has high socio-economic importance as it is considered responsible for the enormous fish catch during monsoon. Fluid mud is associated with high biological productivity as it is rich in organic matter, phytoplankton etc., which attract the fish (Gopinathan and Qasim, 1974). Another remarkable feature of the fluid mud is that it dampens the incident waves due to high suspended sediments thus providing a calm environment for the fishermen to continue fishing while the high monsoon waves inhibit fishing elsewhere. It also protects the beach from erosion during the rough southwest monsoon (Nair et al., 1984). In earlier times, the occurrence of fluid mud was frequent and sustained for a few days to a few months. However, it is a rare phenomenon in recent years and appears for a short period.

Many researchers have attempted to understand the formation, sustenance and dissipation of fluid mud along the southwest coast of India. Some recent studies have been based on: hydrography (Kurup and Varadachari, 1975; Nair, 1985), physical oceanography (Mathew et al., 1995; Jiang and Mehta, 1996; Tatavarti and Narayana, 2006), water quality characteristics (Rao et al., 1984a; Balachandran, 2004) and ecology (Nair et al., 1984; Thompson, 1986) of the mud bank region and physical (Manoj Kumar et al., 1998), sedimentological (Ramachandran and Mallik, 1985; Mallik et al., 1988; Narayana et al., 2008), mineralogical (Nair and Murty 1966; Rao et al., 1984b), geochemical (Sheshappa, 1953; Jacob and Qasim, 1974; Ramachandran, 1989), hydrochemical (Nair and Balchand, 1992) and rheological (Fass, 1995; Jiang and Mehta, 1995) aspects of the mud. Although, some of the characteristics of the fluid mud have been explained by the above studies, its occurrence still remains a mystery.

Some of the prevailing hypotheses on the occurrence of fluid mud are outlined below:

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