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# Geo-microbial studies for the Exploration of Hydrocarbon in part of East Vindhyan Basin, India

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***Summary***

*Geo-microbial prospecting for hydrocarbons is an exploration method based on the vertical seepage of light hydrocarbon gases and their utilization by hydrocarbon oxidizing bacteria. The detection of anomalous population of propane or butane oxidizing bacteria in the surface soils or sediments helps to evaluate the prospects for hydrocarbon exploration. The reconnaissance surface geochemical surveys can be used to guide the location and extent of subsequent seismic coverage. In the present study Geo-microbial prospecting studies for hydrocarbon exploration in part of East Vindhyan Basin have been carried out in reconnaissance pattern to know the prospectivity of the area. The Propane oxidizing bacteria (POB) ranges from 0.1 x $10^2$ to 3.38 x $10^5$ cfu/gm. The bacterial concentration distribution maps show distinct anomalies of high concentration of Propane oxidizing bacteria in the studied area. In the present study the propane oxidizing bacteria were found to be around $10^4$ to $10^5$ cfu/gm of soil sample. The Geo-microbial prospecting studies for hydrocarbon exploration in part of East Vindhyan Basin appears to be good prospects for hydrocarbon exploration.*

## Introduction

Microbial prospecting for hydrocarbon is a surface exploration method based on the premise that light hydrocarbon gases from the sub surface petroleum accumulations migrate upward, in more or less coherent mass, by diffusion, effusion and buoyancy. These lighter hydrocarbon gases ($C_1$-$C_4$) are utilized by a variety of microorganisms present in the sub-soil ecosystem. Bacteria and other microbes play a profound role in the oxidation of migrating hydrocarbons. Their activities are directly or indirectly responsible for many of the diverse surface manifestations of petroleum seepage. These activities, coupled with long-term migration of hydrocarbons, lead to the development of near-surface oxidation-reduction zones that favor the formation of this variety of hydrocarbon-induced chemical and mineralogical changes. This seep-induced alteration is highly complex, and its varied surface expressions have led to the development of an equally varied number of geochemical exploration techniques which includes to detect hydrocarbons and microbial activity, directly in surface and seafloor samples and measure the secondary effects of hydrocarbon-induced alteration (Schumacher, 1996; Saunders et al., 1999). The figure.1 shows a generalized model of hydrocarbon microseepage and hydrocarbon-induced effects on soils and sediments. The hydrocarbon oxidizing bacteria exclusively use these hydrocarbon gases ($C_1$-$C_4$) as their only carbon and energy source for their metabolic activities and growth. The light hydrocarbons utilized by number of bacteria belonging to genera of *Brevibacterium, Corynebacterium, Rhodococcus, Flavobacterium, Mycobacteium, Nocardia, Pseudomonas* etc. These bacteria are found mostly enriched in the shallow soils/ sediments above hydrocarbon bearing structures and can differentiate between hydrocarbon prospective and non-prospective areas. Microbial anomalies have been proved to be reliable indicators of oil and gas in the sub-surface. The direct and positive relationships between the microbial population and the

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hydrocarbon concentration in the soils have been observed in various producing reservoirs worldwide (Miller, 1976; Sealy 1974a; Wagner et al., 2002). The microbial prospecting studies carried out in western part of East Vindhyan basin. The paper presents the results of microbial prospecting studies carried out in part of East Vindhyan basin to know the prospectivity of the area.

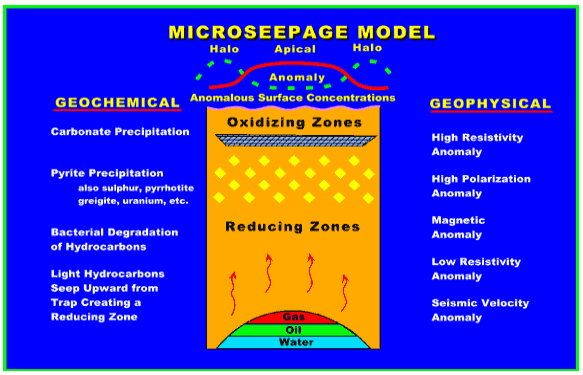


Fig. 1 Hydrocarbon microseepage model and hydrocarbon-induced effects on soils and sediments.

## Geology of Vindhyan basin study area

The Vindhyan basin, located on the Bundelkhand craton in central India, is one of the largest Proterozoic sedimentary basins of India. The Vindhyan rocks crop out over an area of 1,04,000 sq km with cumulative thickness of ~ 4,500m in the central peninsular region. The Vindhyan basin predominantly comprises of shallow marine deposits. The maximum thickness of the basin fill reaches up to 5 km that accumulated during the prolonged history of sedimentation from 1700–700 Ma (Ray *et al* 2002). The Vindhyans are divided into lower and upper Vindhyans separated by a well marked unconfirmity. Major litho units of the Vindhyan basin consist of limestones, sandstones and shales. Major part of the basin consists of unmetamorphosed sediments providing suitable environments for the deposition of hydrocarbons. The occurrence of stromatolitic limestones in the basin proves the abundance of organic life in the Vindhyan sediments. Geochemical studies of some shales in the basin show 1.13% of total organic carbon suggesting the hydrocarbon potential of the basin. The Vindhyan basin is bounded in the NW by the Great Boundary Fault (GBF) and in the south by the Narmada–Son Lineament (NSL). The SW and NE parts of the basin are concealed under the Deccan traps and the Indo-Gangetic alluvium respectively.

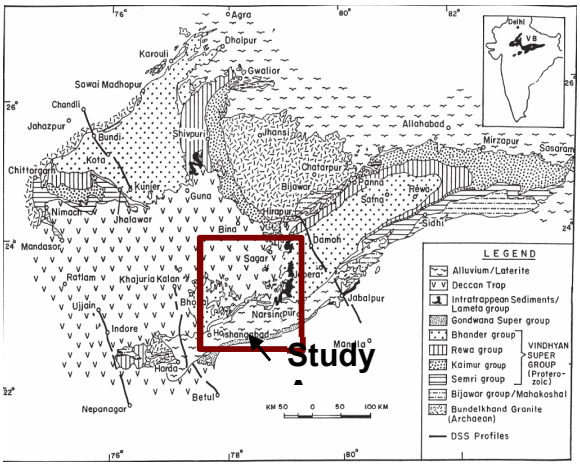


Fig. 1 Geological map of Vindhyan Basin showing the study area (after Rajendra Prasad and Vijaya Rao, 2006).

## Methodology

Sampling was carried out in a reconnaissance pattern along the major roads connecting Sagar -Bhopal – Hoshangabad – Narsimhapur – Sagar and nearby areas (Fig.2). About 50gms of soil samples were collected from the field in pre-sterilized whirl pack bags under aseptic conditions from a depth of about 1m and were stored at $2^0$ to $4^0$C. The isolation of light hydrocarbon oxidizing bacteria is carried out using standard plate count method. The Mineral salts medium (MSM) plates were incubated in the environment of hydrocarbons and zero air (1:1), respectively. The bacterial colonies were reported in Colony forming unit (Cfu/gm) of soil sample. The bacterial population and anomaly maps were prepared using Arc GIS software.

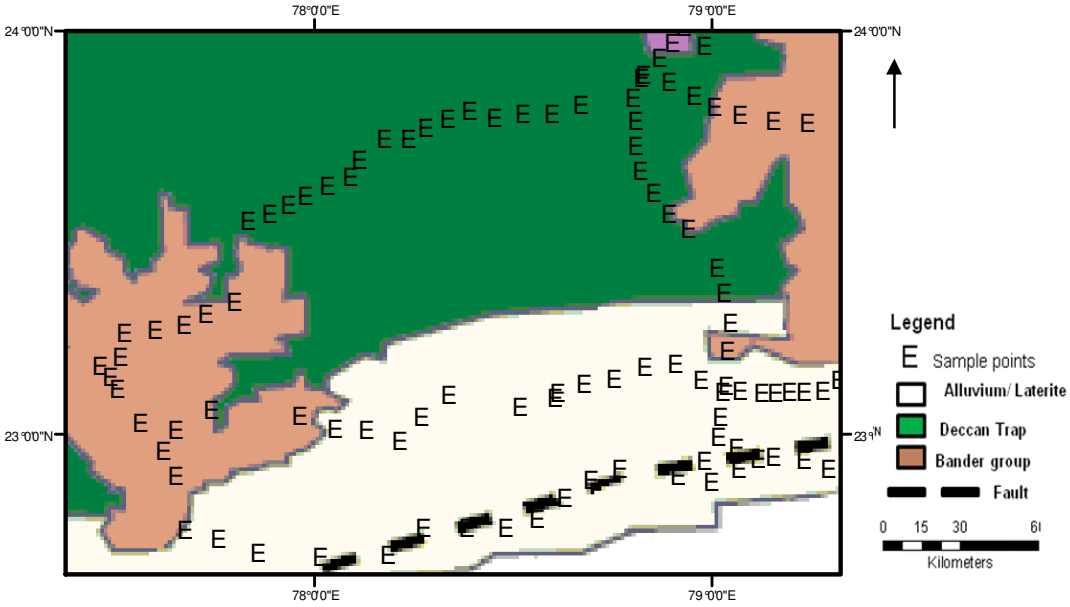


Fig.2 Map showing sample location points in part of East Vindhyan basin.

**Results and Discussion**

The microbial analyses of the sediment samples from part of Vindhyan Basin study area show the Propane oxidizing bacteria (POB) ranges from 0.1 x $10^2$ to 3.38x $10^5$ cfu/gm of soil sample. The arithmetic mean and the standard deviation of bacterial counts are found to be 3.32 x $10^4$ and 5.09 x $10^4$ cfu/gm respectively (Table.1).

Table.1 Statistical analysis of propane oxidizing bacteria (POB) in soil samples from part of Vindhyan Basin.

| Parameter | Propane oxidizing bacteria (POB) |
|---|---|
| No. of samples | 100 |
| Minimum | 0.2 x $10^2$ cfu/gm |
| Maximum | 3.38 x $10^5$ cfu/gm |
| Arithmetic Mean | 3.32 x $10^4$ cfu/gm |
| Standard Deviation | 5.09 x $10^4$ cfu/gm |

**cfu** : colony forming unit

The microbial results indicate the anomalous population of propane oxidizing bacteria were found in survey area. The

bacterial concentration distribution maps shows two distinct anomalies of high concentration of Propane oxidizing bacteria in the north-western and southern parts of the studied area. The possibility of detecting of oil or gas fields using microbial method is emphasized by the fact that the bacterial count of hydrocarbon-oxidizing bacteria in soil or sediment samples is relatively low (compared with non- hydrocarbon-oxidizing bacterial groups). The bacterial count ranges between $10^3$ and $10^6$ cfu/g in soil receiving hydrocarbon micro-seepages, depending on the ecological conditions (Wagner et al., 2002). In the present study the propane oxidizing bacteria were found to be around $10^4$ to $10^5$ cfu/gm of soil. Based on the microbial prospecting results the Vindhyan Basin study area appears to be prospective for hydrocarbon exploration.

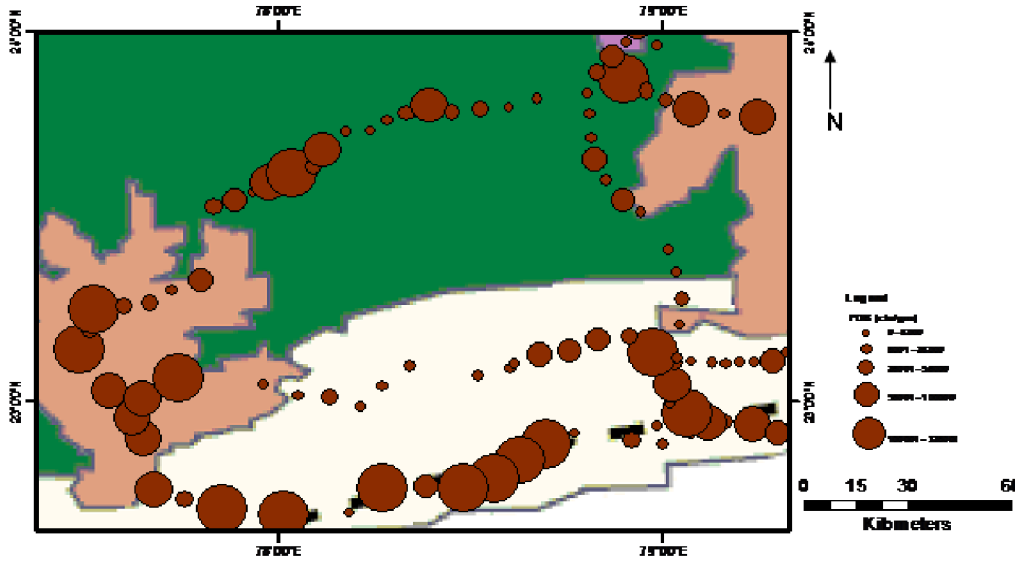


Fig. 2 The concentration distribution map of Propane oxidizing bacteria (POB) in part of East Vindhyan Basin study area.

## Conclusion

The application of Microbial Prospecting method has proved to be a useful and successful supplementary tool in Petroleum exploration and integration of microbial data with geochemical (adsorbed soil gas), along with geological and geophysical data, can lead to the successful grading of exploration leads and prospects. Fault dependent microbial anomaly observed on Narmada–Son Lineament. The Geo-microbial prospecting studies for hydrocarbon exploration in part of East Vindhyan Basin study area appear to be good prospects for hydrocarbon exploration.

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