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Possible Radon concentration over the Indian Seas during the southwest monsoon season on the basis of climatic features of the area and utilization of the Radon results for identifying air masses

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ABSTRACT. Important climatic features during the southwest monsoon season over the north Indian Ocean, the Arabian Sea and the Bay of Bengal have been described, and on the basis of Rama's results that the southeast trades air is poor and the continental air rich in radon, possible concentration of radon over the area has been discussed. It is considered that radon results should be interpreted taking into account the prevailing synoptic features as ordinarily pure air masses may not be present over the Indian Seas north of the equator.

1. Introduction

Rama (1966, 1967) has suggested that it may be possible to decide whether an air mass during the southwest monsoon is primarily from the northern hemisphere itself, *i.e.*, from Arabia and northeast Africa or from the southern hemisphere (Desai 1966), with the help of measurements of radon (half-life 91 hr) content of the air over the Arabian Sea. The basis of Rama's suggestion is that the southeast trades near the equator which later become the deflected trades over the Arabian Sea would be very poor (2-4 dpm/m^3) in radon due to their origin over the sea and long travel, while the continental air from northeast Africa and Arabia would be rich in radon due to shorter period of travel between the Arabian-Somalia coast north of about 10° and the west coast of the Peninsula, the actual time depending on the speed of the wind.

2. Summary of Radon results of Rama

Rama (1968) has given results of cruises between Bombay-Seychelles-Mombasa during July 1966 which show radon values of 20—35* dpm/m^3 over the Arabian Sea north of 5°N both during weak and active monsoon conditions as judged from rainfall on the west coast of the Peninsula; radon values varied from 2—4 dpm/m^3 in the area of the southeast trades and from 45—110 dpm/m^3 near Mombasa. The other results are of cruises between Bombay-Aden-Jedah and they showed radon values of 8—25 dpm/m^3 between Bombay and Aden and 140—160 dpm/m^3 near Jedah (period 12-25 August 1966); during the return voyage (1-9 September 1966) radon values varied from 50—100 dpm/m^3 from near Jedah to about 13°N, 49°E and from 4—25 dpm/m^3 over the rest of the journey to Bombay. During the outward journey the lowest radon value was about 8 dpm/m^3 from near 18°N, 61°E to 17°N, 56°E on 15-16 August and during the inward journey 6—4 dpm/m^3 between 15°N, 56°E and 16°N, 64°E on 6-7 September.

The radon results show that they represent integrated effect of various factors. It is considered that information about climatic features over the Indian Seas and the expected radon concentration on that basis, will help interpreting radon results with reference to the synoptic charts, and the same is given in what follows.

3. Discussion of climatic features over the Indian Seas during the southwest monsoon season and expected Radon values

(*a*) *Surface condition* — It is well-known that during May there is, over the Arabian Sea, air from Arabia and neighbourhood presumably rich in radon and that when it reaches the west coast of the Indian Pennisula, little rain occurs there.

The important difference which one finds on the basis of ships' observations over the Arabian Sea during the monsoon months when compared with May is that there is present in the surface layers of a belt of moderate to strong southwesterly winds 200-500 km wide off the Somalia-Arabia coast between about 6 and

*Rama (1968) has considered decrease in the coastal radon values of 45–160 dpm/m^3 in the continental airmasses from north Africa to 25-35 dpm/m^3 on the Ocean as being due to (1) vertical mixing and (2) decay. Regarding cause (1) it might be stated that because an inversion develops from the surface in the continental air as it travels over the colder sea-surface (Desai 1966, 1968), there will not be significant vertical mixing; as such, appreciable decrease in the radon concentration of the continental airmass will not occur.

18°N; trough of low pressure also extends from Somalia across southeast Arabia to the main heat-low over West Pakistan during the monsoon season. The southwesterly winds veer to west while approaching the west coast of the Peninsula under the influence of the prevailing pressure distribution over the Indian sub-continent. It has been observed that when this cool air with high humidity arrives on the west coast, there is rain. This cool moist air is considered to be a continuation of the south-east trades from the southern hemisphere which move into the Arabian Sea across the equator west of about 60°E. To the west of the trough axis there is drier continental air; this air will be very rich in radon. To the east there will be mixture of continental and deflected trades air masses and the air mass so formed, will have radon content between that of the two air masses. Thus one may find that the radon values over the Arabian Sea is higher than that of the uncontaminated deflected trades air even when the monsoon in terms of rainfall is active or strong on the west coast; when the monsoon is weak, the values of radon in the Arabian Sea east of the trough might be relatively high, although less than in the uncontaminated continental air.

A trough also frequently develops off the west coast south of 20°N when the monsoon is strong or is strengthening. There will be about the same air mass in this trough area on either side of its axis, and the radon values on both the sides of the axis would be about the same.

The deflected trades between about 8°N and equator and the trades south of the equator off the east African coast will have higher radon content than in the trades further east due to mixing with the continental air over and to the west of that coast. Rama (1968) has observed radon values 55—110 dpm/m^3 and 10—45 dpm/m^3 near 5°S within about 200 km of the east African coast. Thus the trades air only further off the African coast would be radon-poor.

As is well known a third trough is also present just south of the equator between 60° and 110°E. The trough will have mixture of the trades air and of the air from west of 60°E and this air can be called even equatorial air; its radon content might be somewhat higher than that of the unadulterated trades. This equatorial air enters Bay directly and radon content of the air over the Bay south of about 8°N and in the southeast Bay, will be much less than of the air over the rest of the Bay north of that latitude, which is ordinarily from the Arabian Sea side but has probably got enriched in radon during its travel across the Peninsula.

(*b*) *Upper air conditions* — The aircraft wind observations over the Arabian Sea at 1500 ft off the Somalia-Arabia coast when the monsoon was active or strong in terms of rainfall on the west coast of the Peninsula, have shown about the same type of wind distribution as at the surface, *i.e.*, 20 to 35 kt southwesterly winds between about 6°N, 46°E and 18°N, 63°E, the speed of the westerly wind decreasing towards the west coast.

Findlater (1966, 1967) has shown that over the flat low-lying area of eastern Kenya which lies astride the equator and on the western edge of the monsoon system, there are to the east of 38°E mainly southerly winds upto about 3·0 km at least during the months April to October; the winds become southwesterly towards the northern Somalia. At times the wind speeds become 40 to 100 kt in the levels about 1·2-2·5 km, most of such occasions occurring during the months June to August. The area of high-speed extends from near Mombasa to near Mogadiscio on the coast and upto the highlands of Kenya to the west. This air mass might have relatively higher radon content as the air near the surface. No data were available to show extent of high speeds over the Indian Ocean off the coast of east Africa.

It has been observed that over the Arabian Sea west of about 65°E, the depth of the deflected trades is 0·5 to 1·5 km; above the deflected trades two different types of air masses have been observed, relatively dry air mass on some occasions and less moist one on others (Desai 1967). The radon content of the upper drier continental air will be much higher than that of the upper less moist air from more southerly latitudes, even if the latter is from Africa south of about 10°N as the convective processes will be less strong than in the former case.

The above air mass stratification moves eastwards towards the west coast of India and within about 500 km of the coast, the inversion base begins to rise and its thickness decreases as the Western Ghats are approached; on the coast the depth of the moist layer becomes about 6·0 km and there are *Cu* and *Cb* clouds and considerable rain (Desai 1966, 1967). As a result of mixing, the radon content will considerably change and the rain water may show very high radon values, particularly on those occasions when there is, above the deflected trades, drier continental air with unstable lapse.

Over the Bay the air mass is more or less homogeneous without an inversion. South of about 8°N and in the southeast Bay there would be air mass with relatively lower radon content than over the rest of the Bay north of that latitude; as such, rain water over the former area may show lower radon values than over the latter area.

In the Arabian Sea, the deflected trades advance north or northeastwards as a wedge, the depth being 2·0 to 3·0 km near the equator west of 60°E and about 1·0 km on the Sind coast (Desai 1967). If a fresh surge of the deflected trades arrives over the Arabian Sea, there would be lower radon content in it than in the moist air it replaces. Thus there might be areas of relatively high values of radon on either side of the fresh surge of the deflected trades. Radon results of Rama during the cruises between Bombay and Jedah in August-September 1966 referred to earlier, show such variations.

From the above discussions of the chief climatic features during the monsoon season and the different amounts of radon which might be expected in air and rain water over different areas, it follows that radon values can be taken as representative of air masses only if they are not contaminated with each other.

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