Measurement of background radiation

The publication by Sulekha Rao *et al.*[1] entails the measurement of radiation in three areas, i.e. Gopalpur, Chhatrapur and Rushikulya along the southern coast of Odisha by deploying TLD badges in different houses and later converting the data into annual dose equivalent in terms of mSv yr^{-1}. The attempt by the authors to measure background radiation of certain areas and then discuss various aspects of radiation and its health effects is quite informative and appreciable. However, certain statements made in the publication, as noted below, may be incorrect and amount to misleading the readers and the public at large.

(i) The abstract includes a statement that 'The average external gamma dose to people residing in the three sectors is 3.77, 4.47 and 3.57 mSv $year^{-1}$ respectively, which is ~3–4 times the international limit of 1 mSv $year^{-1}$.'

To say that the international limit of radiation is 1 mSv yr^{-1} is incorrect. Rather the permissible limit of radioactivity resulted from man-made activity for the general public is 1 mSv yr^{-1} over and above the natural background radiation (http://www.world-nuclear.org/info/Safety-and-Security/Radiation-and-Health/Nuclear-Radiation-and-Health-Effects/). That is, if the natural background radiation of a place is, say 3 mSv yr^{-1}, any man-made activity should not increase the background radiation to more than 3 + 1 = 4 mSv yr^{-1}. This permissible increase of radiation, which is 1 mSv yr^{-1} for the public, is 20 mSv yr^{-1} for the occupational workers. The authors have simply measured the natural background radiation at a particular place. Hence to say that the reading is more than the permissible limit is not only incorrect, but also misleading.

(ii) While discussing about high background radiation areas (HBRAs), the authors have plotted the value of the three areas against national average of some countries (figure 3), which is again a wrong way of data presentation. If the dose rates of three areas are to be plotted on a histogram, they should have been compared with other high background radiation locations of the world, viz. Ramsar in Iran, measuring more than 200 mSv yr^{-1}, Gurapari in Brazil measuring ~40 mSv yr^{-1} and ~20 mSv yr^{-1} in some places in Kerala. It may be noted that in Ramsar, Iran, several hot-water springs are present, and radioactivity is mainly due to radium and its decay products, which have been brought up to the Earth's surface by the hot springs. Historically, visitors as well as residents use this place as a natural spa.

(iii) The authors (p. 602) have mentioned that 'The continuous mining of the beach placers enhances the dose exhibited in this region, as observed in the present study'.

The authors may be aware that every place on the Earth records some amount of radiation. As mentioned by them quoting UNSCEAR in the first sentence of their publication, 'about 87% of the radiation dose received by mankind is from natural sources and the remaining is due to anthropogenic sources.' The natural source includes the inherent intrinsic radionuclides, e.g. U, Th, etc. in any natural substance. Some rocks on the surface of the Earth record higher radioactivity due to the presence of radioactive minerals. But they are all natural background radiation and in no circumstances can be construed as dangerous. The above statement would have been correct provided the authors had recorded the radiation level present during pre-mining activities and then compared it with the values recorded during the mining operations. Therefore, their conclusion is ambiguous and bereft of any facts.

(iv) The last but one sentence of the publication mentions that, 'In addition, the local groundwater aquifers should be isolated to avoid any contamination due to the leaching of radionuclides present'.

It would have been proper if the authors had collected groundwater at different places, measured its radionuclide content, compared with adjoining areas having no mineral deposits before drawing any conclusion.

In the backdrop of the article and otherwise realized many times that not much of information on radiation and environment is available even with advanced community. While the Department of Atomic Energy (DAE) is engaged in public awareness activities countrywide through various mechanisms, it is suggested that educational Institutes should include this aspect in their syllabus at various levels.

1. Sulekha Rao, N., Parial, Kajori, Koide, Hiroaki and Sengupta, D., *Curr. Sci.*, 2015, **109**(3), 600–603.

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Response:

(i) The exploitation of various heavy minerals along the coastal sands of Odisha, is based on wet methods/dredging for more than a decade. This is not the most optimum technique, if the mineralized zones are irregular and discontinuous/heterogeneously distributed, as observed in the present study area. The social and environmental impact in coastal zones or 'riverine places' like Odisha and Andhra Pradesh coast, makes it less efficient compared to other methods being used throughout the world (for similar deposits), like mobile methods with a smaller (environmental) footprint. There are numerous standard references in this regard, which are easily accessible through the internet. It should also be noted that the region studied, as given in our publication, belongs to that which is composed of rocks like charnockites, khondalite, migmatitic gneisses, etc. which have monazites, zircons, xenotime and other radioactive minerals with higher enrichment (of thorium and uranium). These naturally occurring minerals which occur as opaque minerals having very high radioactivity[1–3] contribute to heavily reworked (eroded) sediments depending on a variety of coastal processes like marine transgressions/regressions, storms, fluvial and aeolian activity and precipitation. The concentration of the radionuclides changes drastically depending on the scale/magnitude of the processes, specially during the Quaternary (Holocene). Some of the widely acclaimed studies undertaken indicate that the mining and distribution of heavy mineral deposits associated with naturally occurring radioactive minerals (NORM), need strict regulation from an environmental perspective[4,5]. It has also been reported[6] that extensive mining of heavy mineral placer deposits results in rapidly changing shorelines (considerably affected by dredging/mining operations) which are not only a threat to coastal resources, but specifically in case of the Odisha coast (in addition to these effects), cause a shift in turtle nestling grounds as well. It may be pertinent to note that the natural radiation environment and technological effects on it are closely linked to the geosphere (upper part of lithosphere), hydrosphere and the ambient atmosphere and its coupling, unlike standard synthetic radioactive sources/radionuclides, which does not agree with the arguments provided by Mohanty.

Another important aspect in this regard, is that mining of such deposits enriched in uranium and thorium alters the 'NORM' values at the specific locations and when added to the ambient radiation becomes a part of 'TENORM/TENR'[7]. In general, for numerous field studies undertaken, including those at Fukushima, in spite of the effective dose suggested by ICRP of 1 mSV/yr, the Japanese Government decided to clean up radioactive contaminated areas with additional effective dose of more than 1 mSv/yr (Katsumi Hiroshe, Sophia University, Tokyo, Japan, pers. commun., and his recent publications/widely acclaimed research contributions). Worldwide in relation to exposure to the local, ambient population, 'ALARA' is followed according to the 'standard protocols' developed after the 'Chernobyl' and 'Fukushima' nuclear disaster. A protective action is based on the criterion of radiation dose which is assumed to be critical and is always taken on a lower side, based on various epidemiological studies. This is not just a radiological concept (mostly conceptual), but the effects on the human body due to the enhanced levels of radiation dose (entirely field-based studies) apart from contamination due to contaminated water and food materials, just to name a few. The authors of the present study wish to emphasize the need of reliable 'action limits' as utilized worldwide and also by EPA, USA and EURARE, European Union.

Some relevant references in this regard are provided here[8–18].

(ii) Regarding data (histogram plot) on HBRAs, those on Ramsar, Iran, are primarily treated as a VHBRA (Very High Background Radiation Area), as the source of the same is entirely different, compared to other HBRAs, throughout the world. The inhabitants who live in some houses receive an annual doses as high as 132 mSv from external terrestrial doses[19]. This is almost three times higher than in Kerala, India and Yangjing, China. Using these as natural spa by residents and visitors is rare not leading to considerable cumulative radiation dose and should be dealt with caution in terms of the possible 'radioadaptive responses induced in human lymphocytes of the inhabitants', due to prolonged cumulative exposure, if any, which is a major aspect for further academic/research work at Ramsar being undertaken by various research groups and scientists worldwide. A large number of relevant publications are available in the scientific domain in this regard[20,21].

(iii) With reference to UNSCEAR data/report, this is only valid for a region containing uniform distribution of radionuclides and its exposure to the ambient population. This is not valid for TENR/TENORM due to mining of radioactive materials, as in the present case[7]. It should be noted that radionuclides like uranium and thorium get distributed in various geological materials (rocks and minerals) in a non-uniform/heterogeneous manner depending on the geological process and the time of the same. In geochemical parlance, its behaviour is similar to rare-earths and/or trace elements. This should 'not be compared with any homogenous distribution of radionuclides in typical matrices like synthetic or laboratory based radionuclide sources'.

(iv) Regarding the aspect of groundwater studies in this area, the authors are well aware and well versed with them and have already undertaken extensive work along with other colleagues on the earlier methods like the presence of arsenic and fluorite and its contaminant modelling in various parts of India[22,23]. Recently, an extensive study has been undertaken by us using non-invasive electrical, electromagnetic (geophysical) studies coupled to gamma-ray spectrometry and radon emanometric techniques. Most of these have manifold advantages, specially since these do not require drilling/coring (destructive processes), or the need for locating suitable sites for sampling to be undertaken. It also helps in repeat measurements subsequently, being entirely non-destructive (non-invasive) and helps in imaging the subsurface (earth) structure with ease and rapidity[10,24]. Several of these studies have already been published which has facilitated in our methodology being adopted in terms of data acquisition and robust modeling[25,26]. Quite a number of our publications are getting published[27] or are under various stages of publication.

As regards the last comment that much of the 'information is not available with advanced community', I am really surprised at this naïve argument, since subsequent to the Chernobyl and Fukushima events, more than a few hundred publications are available in reputed journals and some recent books. Mohanty could send a query to 'Research Gate' to get the requisite updates, in this regard, which should be instructive and beneficial. Further, in the entire global academic community 'radiation and environment' does not represent solely on the natural radiation environment, but also depends on the radiological effects and its significance. It covers the entire gamut or aspects of technologically enhanced radiation environment (TENR). These are based on stringent epidemiological studies and other radiobiological aspects on plants and other biota, including the ambient population, primarily due to accumulation/hyper-accumulation, of radionuclides[20,28]. Some of our recent studies around a thermal power plant, also indicates that the long-distance migration of the 'leachate plume' from inland to the coast results in significant migration of contaminants, including those enriched in uranium and thorium[10].

As regards the dissemination of knowledge in this subject area, I have been teaching various courses to our UG and PG students at the Indian Institute of Technology Kharagpur, on nuclear geophysics, radioactivity and geochronology, instrumental methods (including radioactive methods) for the past 27 years. It gives me great pleasure, that most of these students have got core (Geosciences) jobs and quite a large number of them are associated with companies/institutes related to nuclear geosciences/allied aspects. Ten of my Ph D students are working either in India or abroad, in earth science institutes/organizations, related to radioactivity and nuclear studies and various sponsored/consultancy projects as well. I hope that this should amply take care of the dissemination aspect. In addition, some of the aspects have been extensively covered in my (frequent) talks in schools and colleges, in India and abroad, on 'Living with radiation'.

A few additional comments: Subsequent to the publication of our recent manuscript, Indian Rare Earth Limited, published a notification 'regarding the remediation of excavated area of beach placers' by natural vegetation (Enclosure No. 1, T.O.I, Kolkata, 7 April 2016). Is it just sheer coincidence? Does this methodology make the 'mining (placer) environment' sustainable?

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