Radioactivity Distribution in Laboratory Processing of Heavy Minerals Rich Sand from Beach Placers of Bangladesh: A Case Study

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Abstract

Simultaneous measurement of radioactivity and dose rate were carried out at Beach Sand Minerals Exploitation Centre (BSMEC) by scintillation radiation survey meter and portable radiation dose rate meter. The amount of radioactivity and radiation dose were determined in counts per minute (cpm) and micro-Sievert per hour (μSv/hr), respectively. Background radioactivity was found as 10-15 cpm, where the dose rate was observed as 0.5-1 μSv/hr at the same place. Maximum values of radioactivity were found as 3500 cpm and 50 μSv/hr in some processed and stored minerals designated as radioactive concentrate. All data were presented in geographical information system (GIS) software and the relation between activity and dose rate was evaluated. The dose rate was compared with the permissible values. Based on the data, spatial distribution map of the radiation environment of BSMEC was prepared and safety for the occupational workers are recommended.

Keywords: Radioactivity, beach placers, dose rate, radiation safety

1. Introduction

Radioactivity has been frequently reported in heavy mineral rich beach areas of Bangladesh [1-11]. Southeastern coastal belt of Bangladesh is rich in radioactive element containing economic heavy minerals as found by the geological exploration which delineated 17 deposits in both recent and paleo dune areas. Averaging 23% heavy mineral containing sands are being processed in Beach Sand Minerals Exploitation Centre (BSMEC) of Bangladesh Atomic Energy Commission (BAEC) located at Cox's Bazar, Bangladesh [12]. A pilot plant and associated laboratory facilities are present at BSMEC to separate several heavy minerals. Among those minerals, presence of uranium and thorium are confirmed mostly in zircon and monazite assemblages [8- 9], due to which background radioactivity has been found higher in those deposit areas [13]. The radioactivity due to the presence of these radionuclide becomes anomalous when the bulk sands are processed in plant and laboratory of BSMEC and radioactive minerals are concentrated in small space. As the radioactivity becomes high, corresponding doses and their effect to laboratory and plant workers also turns out to be high. The present study assesses these radioactivity contents in accumulated mineral sands in pilot plant of BSMEC and their effective radiation doses to occupational workers.

BSMEC is located at only approximately 250 meters away from the recent beach of Cox's Bazar. The average background radioactivity of Cox's Bazar is higher than other places of the country due to the presence of beach sand that contains radioactive minerals [2-3, 13]. Such radioactive elements have been found not only on surficial and subsurface sands, but also in ground water as well [14-15]. Therefore, it is expected that radioactivity in and around BSMEC campus would be much higher due to the processing of heavy minerals. However, so far there has been no detail radioactive mapping of the area. The present study attempted a preliminary survey to make a radioactive mapping of the plant and laboratory environment, as a case study. Successful completion of the study would help in surveying entire BSMEC premises for a detail distribution of radioactivity and its corresponding radiation doses to the occupational workers as well as inhabitants.

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2. Materials and Methods

The study was conducted through several steps (Fig. 1), such as real time data collection in the field by survey meter and later comparing with literatures values. Small scale radioactive survey was carried out at BSMEC campus using a scintillation radiation survey meter (Model SMGE 12#090202) and a portable radiation dose rate meter (Model MDGE 11#101201), to determine the amount of radioactivity and radiation dose rate in counts per minute (cpm) and micro-Sievert per hour (μSv/hr), respectively. Both the meters were made by Institute of Electronics, BAEC and calibrated with ^{137}Cs source at Secondary Standard Dosimetry Laboratory (SSDL) of Institute of Nuclear Science and Technology, Atomic Energy Research Establishment (AERE), Savar, Dhaka.

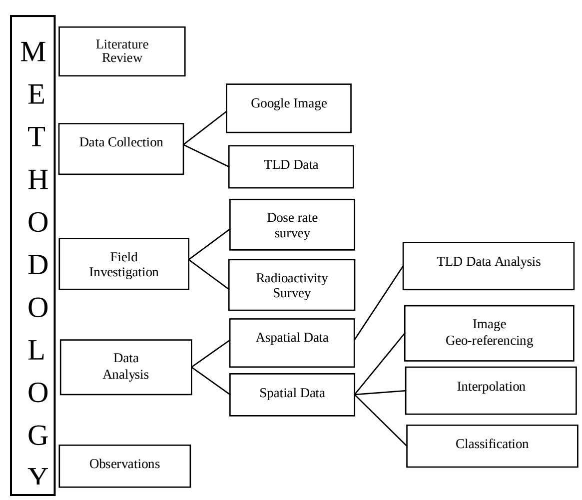

Fig. 1: Study flow chart

Simultaneous measurement of radioactivity and dose rate were carried out in the entire BSMEC plant and laboratories. Grid system of 5x5 meter was adopted to take the measurement at the total premise (Fig. 2), with more frequent spacing at the places where the radioactive minerals are stored. For both measurements, highest counts were taken in 1 minute with 1-minute stable time to eliminate the memory effect. With the help of GIS software, geo-referencing of the google image was carried out to prepare the spatial map of the radioactivity concentration of the BSMEC campus. As the scientific and technical personnel of the center is regularly monitored by thermoluminescence dosimeter (TLD), the corresponding dose rate was also evaluated with the radioactivity in the working environment. The instruments used in this study are also presented in Fig. 3 along with few photographs of the real time data collection at BSMEC laboratories and plants (Fig. 4). The obtained data were compared with few literature values and discussed.

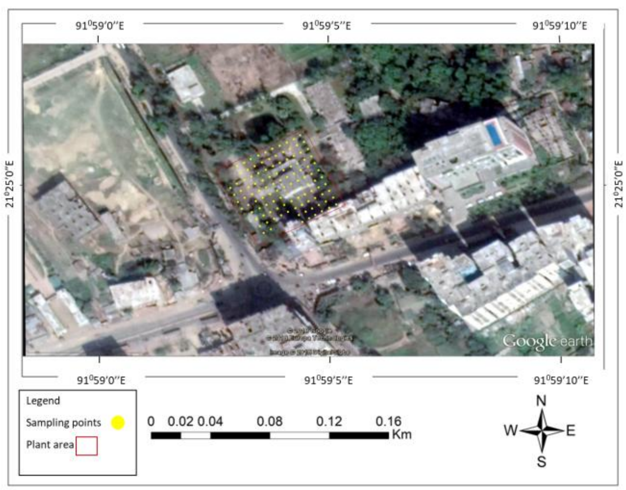

Fig. 2: Sampling grid points at BSMEC campus for radiation survey

(a) (b) (c)

Fig. 3: a) Scintillation radiation survey meter (Model SMGE 12#090202), b) Radiation dose rate meter (Model MDGE 11#101201) and c) Thermoluminescence dosimeter (TLD)

(a) (b)

(c) (d)

Fig. 4: Real time data collection in the mineral processing area of BSMEC

3. Results and Discussion

As many as 115 measurements were taken from the same number of points at the plant and laboratory premise, to obtain radioactivity and radioactive doses. The results showed the values of radioactivity in counts per minute and radiation doses in micro-sievert per hour (Table 1). The data showed the radiation doses of 0.5 μSv/h as lowest. The maximum value was recorded as 100 times higher, 50 μSv/h.

Table 1: Summery of measured radiation dose and radioactivity

	Range of Minimum values	Mean	Range of Maximum values	Mean
Radiation (μSv/h)	0.5-40	4.8	2.5-50	8.2
Converted to mSv/yr		42.048		71.695
Radioactivity (cpm)	25-2000	321	50-3500	449
Converted to cps		19260		26940

The corresponding radioactivity at the same point was measured as 10 cpm as lowest and 3500 cpm at the highest, which is 350 times higher than the minimum value. The values were converted into milli-sievert per year, to compare with the UNSCEAR (2000) [16] guideline of occupational and public exposure limit. The converted results of mean radiation doses were found to be 42.048-71.695 mSv/yr.

The results were found consistent with the recent findings [13] for Cox's Bazar region. Keeping in mind about the WHO limit of radiation exposure: 1 mSv/yr for public and 20 mSv/yr for occupational workers, So that it can be mentioned the radiation dose rate is at least double for the occupational workers at BSMEC campus. The premise is concentrated with approximately 40 times higher radiation for general public.

The radioactivity distribution was presented by GIS software to visualize the concentrated zones at the campus premise (Fig. 5). It is observed that there are several clusters of concentrated radioactivity at the pilot plant area, specially where the processed radioactive minerals are stored in drums (Fig. 4a) and storage area (Fig. 4c). This result also found consistent with the findings of Kabir et al. [6] where correlation of radioactivity and heavy mineral deposition was shown. Zaman et al. [7, 9] and Sasaki et al. [8] confirmed the concentration of radioactivity from the zircon, garnet and monazite assemblages. Since the plant and laboratories deals with the processed minerals where radioactive minerals like zircon and monazite are present, such highly concentrated zones are expected.

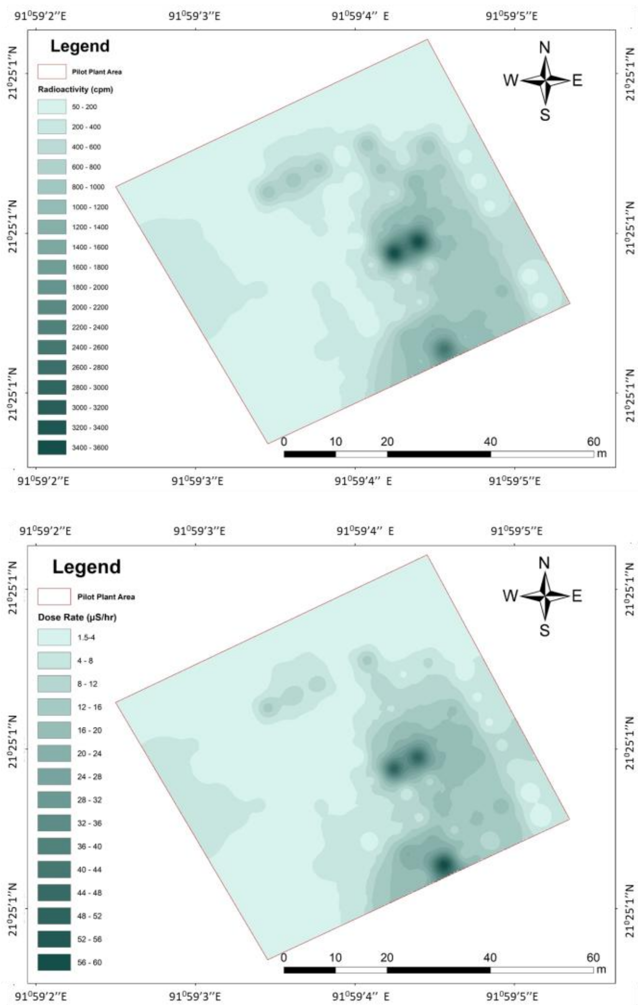

Fig. 5: Radiation dose rate (top) and radioactivity (bottom) distribution at BSMEC laboratory premise

Radioactivity and dose rate at BSMEC campus were found in consistent with each other. At some points of the plant area, the maximum dose rate was observed as 50μSv/hr. Therefore, considering 8 hours a day and 22 days a month, an employee engaged with heavy mineral processing might be exposed to more than 100 mSv/year which is significantly above the dose limit for an occupational worker in a year (20mSv). However, as the effective dose to human health is inversely proportional to distance and time, workers experienced and concerned the radiation dose well within the area of the pilot plant, which is evident from the TLD results. The scientific and technical personnel are regularly monitored by TLD where dose of every four months (one cycle) are analyzed by the Health Physics Division of Atomic Energy Centre, Dhaka. Considering the minimum level of detection, less than 0.05 mSV/year is reported as zero and there has been only one record of an employee to have effective dose of 0.098 mSv/yr in one cycle. The reason of that higher dose was found to be due to keeping the TLD near the processing area of the pilot plant for 24 hours. Therefore, the study revealed that risk of radiation safety for the personnel working at mineral processing plant and laboratory of BSMEC is minimum provided that the minerals are stored far enough from the frequent work space, i.e. following 'as low as reasonably achievable (ALARA)' principle.

4. Conclusion

Small scale measurement of radioactivity and its corresponding radiation doses has been successfully carried out from the real time data with portable survey meters for the BSMEC campus. Quite a good number of samples in relatively small area was the key feature of the survey, therefore, presenting a very detail radioactive distribution map of the office campus. Such type of survey can be extended to a larger scale, especially at the beach environment, to obtain radioactive contour map of the region. This will be beneficial for the public health administration, as well as management of the millions of tourists visiting one of the most beautiful tourist attraction of the country.

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