Updating of baseline radionuclides concentration in Jakarta Bay

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Abstract. Jakarta Bay receives a variety of pollutants including radioactive substances originating from industry and operating the Serpong nuclear area in South Tangerang. Radionuclide types that have the potential to enter Jakarta Bay are anthropogenic or primordial radionuclides originating from the Serpong nuclear area and factory. Whereas the input of natural radionuclides originating from the use of industrial raw materials and terrestrial run-off. Monitoring is carried out twice a year on the coast of the bay of Jakarta. Monitoring results showed primordial radionuclide concentrations were in normal condition and originated from global fallout. This is shown from the ratio of \(^{226}\)Ra concentration which is the character of the Pacific Ocean before the nuclear accident at Fukushima. On the other hand, artificial radionuclides are in normal conditions and do not exceed the threshold.

1. Introduction
The utilization of radionuclides in the field of research and health in Jakarta and surrounding areas is still relatively popular such as the use of nuclear reactor research in Serpong and use in factory. All these activities have the potential for residue and waste wasted and polluting the environment. The largest and closest ecosystem that has potentially dangerous consequences of this is Jakarta Bay. Jakarta Bay itself is a downstream of dozens of rivers that allow the waste of radionuclides, as the radionuclides brought into as the \(^{226}\)Ra lays that are settled in soil and have a long half-life (T\(_{1/2}\) 1600th) [1].

The monitoring of Jakarta Bay is still limited. The study radioecology at Jakarta bay have been conducted for environmental monitoring of \(^{137}\)Cs and \(^{239/240}\)Pu in water, sediment and in some marine biotas [2]. The \(^{137}\)Cs bioaccumulation studies have also been carried out using one compartment biokinetic methods [3][4]. Some researches concerning environment monitoring have been conducted at Jakarta Bay [5]. If viewed from some previous research, the potential accumulation of radioactive waste will be very dangerous. On radionuclides that have a long half-life and potential entry into the body organs of life such as \(^{137}\)Cs and \(^{226}\)Ra. \(^{226}\)Ra is a heavy metal that is one of the primordial radionuclides \(^{238}\)U. Despite having a relatively small probability, \(^{226}\)Ra secretes gamma energy to achieve stability at the core. In nature, \(^{226}\)Ra unlike \(^{137}\)Cs that are water-soluble, \(^{226}\)Ra have a greater mass therefore have the likelihood of settle in the sediment, even though the \(^{137}\)Cs also still have the
possibility of also to settle in sediments [1]. The spread of $^{226}$Ra is also influenced by the flow of water flows, the greater the direction, the wider also the spread of $^{226}$Ra [6]. The risk of propagation of radium has become a problem in public health because of its harmful nature in relation to internal hazards. In addition, $^{226}$Ra can be concentrated in the bones, leading to the increase in the dose of individual internal radiation [7]. From the publication the importance of this monitoring is done periodically to see the accumulation of radionuclides in addition to update the baseline of the data for radionuclide in Jakarta Bay. In this paper will discuss the centralization of the primordial radionuclides $^{226}$Ra and $^{137}$Cs located in the sediment in the Jakarta Bay.

2. Experimental method of determining radium

Samples of sediment on this research were taken directly in Jakarta Bay. Sampling was conducted in January 2020 at 5 points adjacent to previous monitoring[2]. Many methodologists in the calculation of $^{226}$Ra. But in this paper, $^{226}$Ra measurement methodology uses $\gamma$-Ray spectrometry method [7]. The preparation of sediment samples is more physical. A total of 1.5-2 kg of wet sediment is taken at each sampling point. Sediment is then dried in the oven (Memmert, Germany) for several days to eliminate moisture content. Sediment that dries and hardens then in grinding (Fritsch, Germany) until smooth. A total of 1 kg of sediment is then inserted into Marinelli. The Marinelli containers were sealed and left for a period of about 30 days which then samples were ready to analysis in high-purity germanium (HPGe) detectors (will of 20-25%) Canberra and Ortec. In the measurement process, HPGE has done routine calibration well, carried out efficiency measurements, carried out the cumulative addition of the sediment samples obtained, and monitor the background of the detector shield periodically.

3. Results and discussions

3.1. $^{226}$Ra concentration

Based on the gamma Spectrometer analysis, the $^{226}$Ra concentration in sea sediment of Jakarta Bay has a sufficient result options in range of 42.00-64.92 Bq kg$^{-1}$ as seen in Table 1. This Range is much smaller compared to other regions in Indonesia with an average of 66.07-95.24 Bq kg$^{-1}$ [8]. If we compare with neighboring countries such as Thailand. $^{226}$Ra concentrations in Thailand are not much different from the Indonesian and relatively smaller concentration ranges from 2.9 – 53.2 Bq kg$^{-1}$[9]. On the other side, the result activity of $^{226}$Ra in Jakarta Bay quite comparable with previous study in Kalimantan Waters with value 1.09 ± 0.41 - 53.46 ± 1.47 Bq kg$^{-1}$[6].

| Location | $^{226}$Ra (Bq kg$^{-1}$) | $^{137}$Cs (Bq kg$^{-1}$) |
|----------|----------------------|----------------------|
| 106°31’46” E, 06°00’ 21,3” S | 45.80 ± 5.32 | 1.63 ± 0.14 |
| 106°34’ 30,5” E, 06°01’ 56,7” S | 42.00 ± 5.56 | 0.42 ± 0.08 |
| 106° 36,8’ 30.3” E, 06°00’35.1” S | 64.92 ± 8.01 | 0.21 ± 0.05 |
| 106° 39’ 45.9” E, 06°01’ 10.1” S | 55.64 ± 8.72 | 0.81 ± 0.09 |
| 106° 42’ 15.7” E, 06°00’ 55.6” S | 48.82 ± 8.21 | 1.27 ± 0.03 |

This difference can occur due to the activity of steam power plants that use coal fuel in the Sluke Waters that cause an increasing of radionuclides $^{226}$Ra. When compared to some other countries, $^{226}$Ra can still be said in the background level.

The existence of $^{226}$Ra in Jakarta Bay can be caused by the activity of nuclear research reactor in Serpong. In addition, other activities that have the potential cause the survival of $^{226}$Ra in Jakarta Bay.
such as waste from mining factories [7]. Waste or residue from these activities are carried over by rivers in Jakarta. In this study, a river that affects the existence of $^{226}$Ra at the point of location is the area of the river Cisadane. Nevertheless, $^{226}$Ra in the Bay of Jakarta is still better than the Sluke Waters. This signifies the activity of nuclear research reactor in Serpong is much more orderly and cleaner than steam power plants in Sluke Rembang.

If viewed from the table. Point closest to Cisadane River is point number 3. If viewed from the data, this point number 3 is greater than the other point. This point allows for the waste and residue of $^{226}$Ra from the Cisadane River. While the other points get a $^{226}$Ra spread from the surrounding sea water flow. However, from the accumulated $^{226}$Ra previously described in the background level. The more comprehensive monitoring data is required to see the increase of $^{226}$Ra in Jakarta Bay. In addition, more complex data can also conclude the reason why the data was stabbed 4 and 5 higher than the 1-2 point.

3.2. $^{137}$Cs concentration

While the concentration of $^{137}$Cs in Sediment has a similar concentration on previous research conducted by Heny Suseno et al [2]. In this study the concentration of $^{137}$Cs ranged 0.21-1.63 Bq kg$^{-1}$. The range obtained is greater than the previous study at the range of 0.34-1.21 Bq kg$^{-1}$. Although it has a rising likelihood, it can still be said to be very small concentrations and typical of the background level. If viewed from the table above, the spread of $^{137}$Cs is quite difficult to explain. Based on analysis by gamma spectrometer at sample point to 3, $^{137}$Cs near the Cisadane River is much smaller compared to other points. The author assumes due to the water-soluble $^{137}$Cs which causes these particles near the downstream of the river to be smaller than other sample points. Low deposition capability leads to a longer time to settle in sediment. Therefore, when compared to the activities of $^{137}$Cs and $^{226}$Ra in the sediment gained, $^{226}$Ra has a higher activity.

### Table 2. Input and parameter ERICA

| Matrix                  | $^{226}$Ra | $^{137}$Cs |
|-------------------------|------------|------------|
| Activity Concentration in sediment | 64.92 ± 8.01 | 1.63 ± 0.14 |
| Distribution Coefficient (Kd) [L kg$^{-1}$] | 5.33x10$^{3}$ | 1.07x10$^{4}$ |

3.3. Risk analysis of $^{137}$Cs and $^{226}$Ra

Based on the data obtained, although $^{137}$Cs and $^{226}$Ra still in the background level, it cannot be denied that the biotas around Jakarta Bay still has the ability to accumulate radioactive substances [2][9][10]. Based on the available data, the risk analysis in the biota can be calculated by entering the data into the ERIC tool. By using the highest sediment data input from the monitoring results and the value of KD from the data on ERICA preparations based on the IAEA (2004) - ocean margin - based on assumption that min max 1 order of magnitude around the recommended values given in TRS422 = 5th and 95th percentiles (Table 2), we can obtained the total dose rate data on every biota in Jakarta Bay.

### Table 3. Assesment for total dose rate

| Organism        | $^{226}$Ra Dose rate (µGy h$^{-1}$) | $^{137}$Cs Dose rate per organism (µGy h$^{-1}$) | Screening Value (µGy h$^{-1}$) |
|-----------------|-----------------------------------|-----------------------------------------------|-------------------------------|
| Benthic fish    | 0.262                             | 2.47x10$^{-4}$                                | 10                            |
| Pelagic fish    | 0.228                             | 2.56x10$^{-6}$                                | 10                            |
| Crustacean      | 0.180                             | 2.38x10$^{-4}$                                | 10                            |

The results of the risk analysis in several biota in Jakarta Bay listed in Table 2. Based on the results of the table, the difference between the dose rate of $^{137}$Cs with $^{226}$Ra on the three biota is quite
significant. This may occur because the concentration of $^{226}$Ra in the sediment is much higher than the $^{137}$Cs. Because the very small dose rate of $^{137}$Cs, the total dose rate of the biota equals the dose rate of $^{226}$Ra. From the total dose rate results of the three-biota data is still far below the screening dose rate ($10 \mu$Gy h$^{-1}$). This indicates that the lower possible impact on the marine biota because the total concentration of the dose rate is still within the allowed range[12].

Based on several previous research studies, the accumulation of $^{226}$Ra in the biotas is greater than the accumulation of biota in $^{137}$Cs. If from the comparison of both the properties of radionuclides, the possibility of greater accumulation indeed $^{226}$Ra, over $^{226}$Ra can accumulate in the bones and around soft tissues [11]. Override it all, both $^{226}$Ra and $^{137}$Cs have a potential accumulation in the biota and will be dangerous if consumed by humans. Therefore, the importance of this paper as a baseline data reference in the Jakarta Bay and to see the development of the accumulated $^{226}$Ra and $^{137}$Cs in this water.

4. Conclusions

Five samples obtained from various places in the Jakarta Bay has been analyzed well using gamma spectrometer to see the accumulation of substances radionuclide $^{226}$Ra and $^{137}$Cs. Both radionuclides are still in safe and typical levels in the background level. The baseline level $^{226}$Ra and $^{137}$Cs in sediment has a range of 42-64.92 Bq kg$^{-1}$ and 0.21-1.63 Bq kg$^{-1}$ respectively. Based on the outcome of the ERICA assessment, total dose rates of the three biotas are still much lower than the screening dose rate ($10 \mu$Gy h$^{-1}$). From the results of this study and previous studies showed that as small as any accumulation increase would be very influential also against the accumulation of biota, therefore monitoring the radionuclides substance should be carried out.

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**Acknowledgements**

Thank to Prof. Dr. Heny Suseno for material and scientific supports. Yogi Priasetyono is a main contributor to this paper.