Journal of Physics Special Topics

P3_3 Radiation Study around nuclear plant in Fukushima

J. Bettles, I. Clarke, M. Perry and N. Pilkington.

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH.

November 13, 2011

Abstract

This paper investigates possible health effects of the recent Fukushima nuclear emergency. We look at the gamma dose rates at Onami, 62km away from the facility, and the adverse effects it could potentially have upon its residents over the following year. From an absorbed dose of 9.1μSv hr^{-1} it was calculated that 79.7mSv yr^{-1} would be the effective dose. A 0.399% chance of getting cancer from the incident, corresponding to around 399 cancer cases for every 100,000 people affected.

Introduction

On the 22nd March 2011 a tsunami hit Japan and the nuclear reactor at Fukushima had to be shut down to reduce risk to its surrounding population. This paper looks at the area surrounding the nuclear plant and the adverse effects on health that could be attributed to this disaster based upon the radiation emitted. The effects of gamma radiation were investigated as these contribute to most of the primary radiation at Onami 62km away from the nuclear reactor.

Dose Rate

The dose rate at Onami was measured to be 9.1μSv hr^{-1} on 22nd March 2011[1]. The equivalent dose D_{eq} is a function of the absorbed dose D_a and a radiation weighting factor W_r, as given by equation (1)[2],

$$D_{eq} = D_a * W_r \,, \tag{1}$$

W_r is a measure of how effective each type of radiation is at affecting living tissue. For gamma radiation, W_r = 1. The absorbed dose rate refers to the amount of radiation a body receives. The absorbed dose of 9.1μSv hr^{-1} recorded at Onami was chosen as it was the highest dose recorded and would represent an upper bound or worst case scenario for the local residents.

Inserting values into equation (1) yields a result of 79.8mSv yr^{-1} for the equivalent dose of radiation. The maximum dose for radiation workers is 20mSv yr^{-1} when averaged over 5 years with a maximum of 50mSv for one year [3]. This dose of 79.7mSv yr^{-1} is very high; however it does not take into account the peak and rapid decay of levels of radiation. Still, it does pose a high threat to the population initially. It should be noted that there will be some background radiation and this would need to be taken into account to improve the data used along with more precise measurements each month to account for the gradual decrease back to normal levels.

Risks Associated

The next step is to look at the effects of being exposed to this level of radiation; how it deteriorates health and living tissues. Radiation can affect the body in several ways dependant on the amount of radiation and the location on the body where it is absorbed. The value of 79.7mSv yr^{-1} would have no permanent effects since symptoms of acute radiation sickness do not start showing until the equivalent dose is ten times the value obtained [4]. This suggests that the nearby population of Onami will not suffer any adverse effects from this one incident.

Likelihood of cancerous conditions

The final consideration taken was the risk of cancer. This was found using equation (2) below, Radiation around Fukushima, November 13, 2011.

$R = D_{eq} * F_r$, (2)[5]

where *R* is the risk of getting fatal cancer expressed as a percentage, and *F* is the dose-risk factor which has a value of 0.05 Sv^{-1} [5]. Putting in the value calculated earlier for the equivalent dose, the value obtained for the risk of getting cancer was 0.399%. This is equivalent to 399 people in every 100,000 getting cancer due to this exposure. In 2001 Japan had a population of around 127 million [6] with approximately 569 thousand cases of cancer [7], this means that the likelihood of getting cancer is around 448 cases for every 100,000 people. These two figures are of a comparable scale resulting in a large increase in the chance of getting cancer due to the nuclear reactor.

Conclusion

In conclusion the data calculated seems to provide evidence that the nuclear disaster has increased the likelihood of getting radiation related illnesses. From an absorbed dose of 9.1μSv hr^{-1} it was calculated that 79.7mSv yr^{-1} would be the effective dose. This resulted in an extra 399 people in every 100,000 getting cancer as a result of this nuclear disaster. This paper could be improved by looking at the initial radiation levels and how they vary over time, this would reduce the absorbed dose for the surrounding population and hence the calculated chance of getting cancer due to this incident would also be reduced.

References

[1] IAEA Briefing on Fukushima Nuclear Emergency (22 March 2011) – http://www.slideshare.net/iaea/iaea-briefing-on-fukushima-nuclear-emergency-22-march-2011-1530-utc. This report was created on 22/3/11 and accessed on 26/10/11.
[2] Martin, A. & Harbison, S.A. (1996) An Introduction to Radiation Protection – Fourth edition, *p24*.
[3] Martin, A. & Harbison, S.A. (1996) An Introduction to Radiation Protection – Fourth edition, *p55*.
[4] – Straume, T. *et al.* (2010) *Journal of Cosmology*, *12*, 3992-4033, Table 6.
[5] Martin, A. & Harbison, S.A. (1996) An Introduction to Radiation Protection – Fourth edition, *p38*.[6] Japan population 2001 – http://ganjoho.jp/data/public/statistics/backnumber/2010/files/fig03.pdf. Accessed on 13/11/11.
[7] Cancer incidence in Japan – http://ganjoho.jp/data/public/statistics/backnumber/odjrh3000000o8is-att/DATA04.PDF. Accessed on 13/11/11.