Prediction of Diffusion of Cs-137 Atmospheric Contamination near Chernobyl Using Levy Flights

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The Chernobyl nuclear accident occurred on April 26, 1986. It was the worst nuclear accident that large quantities of radioactive nuclide of reactor number four at the Chernobyl plant was released into the extremely broad range of atmosphere, because nuclear reactor core was on fire and continued releasing radioactive materials for more than a week.

Not only in near Chernobyl plant but also at a 200 km or more radius of the power plant there were heavily-concentrated polluted area.

Cs-137 released from the accident posed a big problem. It has a long half-life (about 30 years) and migrates a long distance, and is easily absorbed by foods and vegetables. It is said amount of Cs-137 released from the accident is several hundred times as large as amount of it in atomic bombing of Hiroshima. So it have been still spread by contamination of Cs-137 by resuspension, and radioactivity level near Chernobyl plant is higher than radiation measuring instrument.

Now, there are many model formulas on the air pollution prediction. But none of models can exactly calculate expansion of air pollution after long time. It is necessary to study more accurate long-term and wide-area contamination prediction. The purpose of research is to stochastically clarify the mechanism of diffusion of radioactive pollutants using fractal-based Levy flights. The Levy flight is a type of random walk in which the jump distance is distributed according to a heavy-tailed distribution. For the Levy flight the heavy-tailed probability distribution used is a power law of the form P(r) = r^{-D} where D is no fewer than 1, nor more than 3 and therefore has an infinite variance. P(r) is probability distribution, r is a jump distance, D is fractal dimension. According to the central limit theorem, if the distribution were to have a finite variance, then after a large number of steps, the distance from the origin of the random walk would tend to a normal distribution. In contrast, if the distribution is heavy-tailed, then after a large number of steps, the distance from origin of random walk will tend to a Levy distribution. The Levy flight is part of a class of Markov processes.

First, we ran the simulation of Levy flights, and analyzed the result of the simulation. Secondly we analyzed actual data and compared to simulation result. Actual data used is contained in *JAERI-Data/Code2002-024* published by Japan Atomic Energy Research Institute. Especially we used the contour map of the concentration of Cs-137 in the air at 30 km zone and amount of deposition of Cs-137 at 30 km zone from 1987 to 1999.

As a result, on space dependence actual data of air concentration is well fit with the Levy flight. But amount of deposition is less-accurate fit. When we surveyed time dependence, we calculated average traveling distance from origin position of Cs-137. On time dependence both of actual data are not fit with the simulation. So refining model formula of the Levy flight is necessary. Consequently we take time decay of radioactive pollutant into consideration, and suggest new model formula depended on the Levy flight. As a result, we found that behavior of Cs-137 in space and time is best fit with new model formula depended on the Levy flight.