STATISTICAL CORRELATION OF ENVIRONMENTAL TRITIUM VALUES AT TROMBAY

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In the immediate neighborhood of a nuclear reactor releasing tritium into the environment, tritium monitoring is carried out as part of environmental surveillance in many nuclear centres in the world. The estimated doses from tritium releases have been reported by many workers (1-3). In almost all the cases the data is represented in a conventional way of diurnal, monthly or seasonal variations of discrete values.

As part of the present work tritium releases from a 40 MW(th) D_2O moderated reactor (Cirus) at Trombay and the environmental tritium concentrations (ambient air and vegetation samples) at different ground staticns have been measured over a period of five years and the statistical correlation among the different sets of values were assessed. Sampling stations were chosen in the proximity of the reactor primarily with a view to obtain positive measurable values to yield statistically significant data base, for a meaningful interpretation. The three ground stations chosen were situated at 1500' NNE, 2500' NNE and 3000' SSW. Airsamples were collected using the 'coldstrip' method and vegetation samples (leaves of mango-Mangifera Indica,L.), processed by vacuum freeze drying technique. Tritium measurements were carried out with a Liquid Scintillation Spectrometer (Packard-Model 3255) with a detection limit of 0.8 $\pm$ 0.13 pCi/ml. for aqueous phase.

EXPERIMENTAL RESULTS AND DISCUSSION

The variation in the values of daily releases from Cirus reactor was quite low (of the order of a few tenths of a pCi/ml). The ambient air concentrations at the Ground Stations were usually of the order of a few nCi/m^3 with considerable variations around the mean. Similarly the aqueous samples extracted from the vegetation samples were of the order of a few pCi/ml and showed large variations around the mean. Normally these values are represented as discrete diurnal variations or in histograms indicating monthly or seasonal variations. Most of the earlier workers' attempt didnot extend beyond the determination of mean values of such data for different applications such as dilution rate factor determination etc.

The yearly cumulative frequency distribution of different sets of measured values were drawn on the basis of the method suggested by Seigmund Brandt (4). In all the three sets of distributions representing release values, ambient air concentrations and the vegetation samples similar patterns, having positively skewed normal distribution, were observed. These were caused by the occassional larger release concentrations of tritium which get reflected in the ambient air and

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the water compartment of the vegetation samples. Thus the median values are effectively shifted towards higher values.

The median values corresponding to the 50% fractiles, giving central values insize in each set of observations, as seen in a fractional frequency distribution pattern, differed widely from the mean values. (See Table I). The most probable values for a typical year are also given paranthesis in Table I for the sake of comparison.

TABLE I Average Tritium Concentration Values

Year	Tritium Concentration Values					
	at release point		in ambient air at Station A*		in vegetation samples at Station A*	
	Median	Mean	Median	Mean	Median	Mean
	pCi/cc	pCi/cc	nCi/m^3	nCi/m^3	pCi/ml	pCi/ml
1975	1.23	0.78	3.20	2.80	-	-
1976	0.90	0.60	6.10	3.90	334	330
1977	0.74	0.39	3.96	2.80	539	390
	(0.74)			(1.50)		(350)

* 1500' NNE

The cumulative probability curves for the different sets of values obtained at the different sampling stations also indicated very clearly that all the three distributions corresponding to the release concentrations of tritium, ambient air concentrations and the vegetation sample values showed positively skewed normal distribution patterns.

Inorder to test statistical correlation among the tritium concentration values at the release point and at the ground stations, the sample correlation coefficient, r, was calculated using the expression

$$r = \Sigma x_i y_i \Big/ \sqrt{\Sigma x_i^2 \cdot \Sigma y_i^2} \qquad \text{.....(1)}$$

where x_i and y_i were the observed values for the bivariates taken up for analysis. In case of different sets of observations at different stations, interrelationship among the different bivariates can be obtained as a correlation matrix $\lceil r_{ij} \rceil$. The sample correlation coefficients calculated for a 6x6 matrix was corrected for skewness using the expression

$$z = \frac{1}{2}\left\{ \ln(1+r) - \ln(1-r) \right\} \qquad \text{.....(2)}$$

The population correlation coefficient, ρ , as calcuated on the basis of the expression

$$\rho = \Sigma x_i y_i - n \cdot \bar{x} \cdot \bar{y} \Big/ n \cdot \sigma_x \cdot \sigma_y \qquad \text{.....(3)}$$

were found to be nonzero, and indicated good correlation among the sets of values. Table II gives a set of typical values for three bivariates viz. tritium concentration values at the release point, ambient air concentrations and the condensates (aqueous) and the vegetation sample values. It can be seen that there is excellent correlation among the sets of values (better than 95%) both for sample correlation as well as for population correlation.

TABLE II Typical set of Correlation Coefficients Obtained

Sample Variables x_i	y_i	Degrees of freedom for r	Values of r	Corrected values z	% of significance	Degrees of freedom for ρ	% of significance
X2	X4	30	0.678	0.829	99	80	99
X2 (Aq)	X4	30	0.371	0.388	95	80	99
X1	X2	30	0.538	0.604	99	80	99

X1 : Tritium Conc. at Release Point (pCi/cc)
X2 and X2 (Aq) : Ambient Air concentrations at Station A in gaseous (vapour) and liquid phase. (nCi/m^3 and pCi/ml respectively)
X4 : Vegetation Sample Values at Station A (pCi/ml)

In order to test the interrelationships among the vegetation samples at different ground stations to those of air concentrations, the correlation matrix (5x5), corrected, were found to be well within 99% statistical significance. Thus the correlation among the ambient air concentrations and the water compartments of the vegetation was found to be statistically significant based on a set of environmental samples collected over a long period of time. It is emphasised that the above relationships were among the distributions themselves rather than among the discrete sample values.

The scatter diagram drawn for a set of bivariates has shown that for a fixed value of one variable there were a whole lot of population of values for the other variable indicating the influence of the environmental parameters on the sets of data. The propensity of the sample correlation coefficient, r, is normally reflected by the points which lie in a band in the scatter diagram, often shaped like an ellipse with its major axis sloping towards the appropriate direction depending on the polarity of 'r'. In the present case, where $r \neq \pm 1$, a pair of stright lines indicating the scatter of values around a mean value was obtained.

Thus in all cases it was clearly established that the statistical significance among the environmental tritium values, when taken up as a whole for a long period of time, was found to be excellent.

Utlising the values obtained from the above sets of values, the mean, median and the most probable values were obtained. The dilution rate factor, K ($m^3 . sec^{-1}$), was calculated for the Trombay environs using all the above values to study whether there are variations in the dilution rate factors due to the skewed nature of distribution of tritium in the environment. Table III summarises the values thus

obtained for three years. It is significant that the values obtained on the basis of the present study shows a lower value than the earlier results reported (5).

TABLE III Dilution Rate Factors (K)

Year	Based on Mean Values	Based on Median Values	Earlier Published Data(5)
1975	$0.13-0.38 \times 10^4$	0.28×10^4	$1.0 - 2.8 \times 10^4$
1976	0.10×10^4	0.23×10^4	
1977	0.10×10^4	0.29×10^4	
		(0.19×10^4)	

Value in paranthesis is based on most probable value.

CONCLUSION

The distribution patterns of environmental tritium in and around a reactor site on the basis of a set of data generated over a period of five years have shown that all the distributions are gaussian in nature with identifiable skewness, caused by occasional larger release. The effect of the mean, median and the most probable values on dilution rate factors were found to be significant. The correlation among the sets of data showing tritium concentrations in release air, the ambient air and the vegetation samples at different stations were found to be statistically good, and very nearly perfect.

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