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 stations 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 reac-
tor primarily with a view to obtain positive measurable values to
yield statistically significant data base, for a meaningful interpre-
tation. 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 represen-
ting 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/m³	nCi/m³	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 (0.74)	0.39	3.96	2.80 (1.50)	539	390 (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 vegeta-
tion 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

$$ r = \sum x_i \cdot y_i \; / \; \sqrt{\sum x_i^2 \cdot \sum y_i^2} \qquad \ldots\ldots\ldots(1) $$

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 $\underline{/\,r_{ij}\,\underline{/}}$. The sample correla-
tion coefficients calculated for a 6x6 matrix was corrected for
skewness using the expression

$$ z = \tfrac{1}{2} \left\{ \ln(1+r) - \ln(1-r) \right\} \qquad \ldots\ldots\ldots(2) $$

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

$$ \rho = \sum x_i \cdot y_i - n \cdot \bar{x} \cdot \tilde{y} \Big/ n \cdot \sigma_x \cdot \sigma_y \qquad \ldots\ldots\ldots(3) $$

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		Degrees of freedom for	Values of	Corrected values	% of sign-ific-ance	Degr-ees of freed-dom for ρ	% of signi-fican-ce
x_i	y_i	r	r	z			
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 correla-
tion 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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