Environmental Modeling of tritium in India
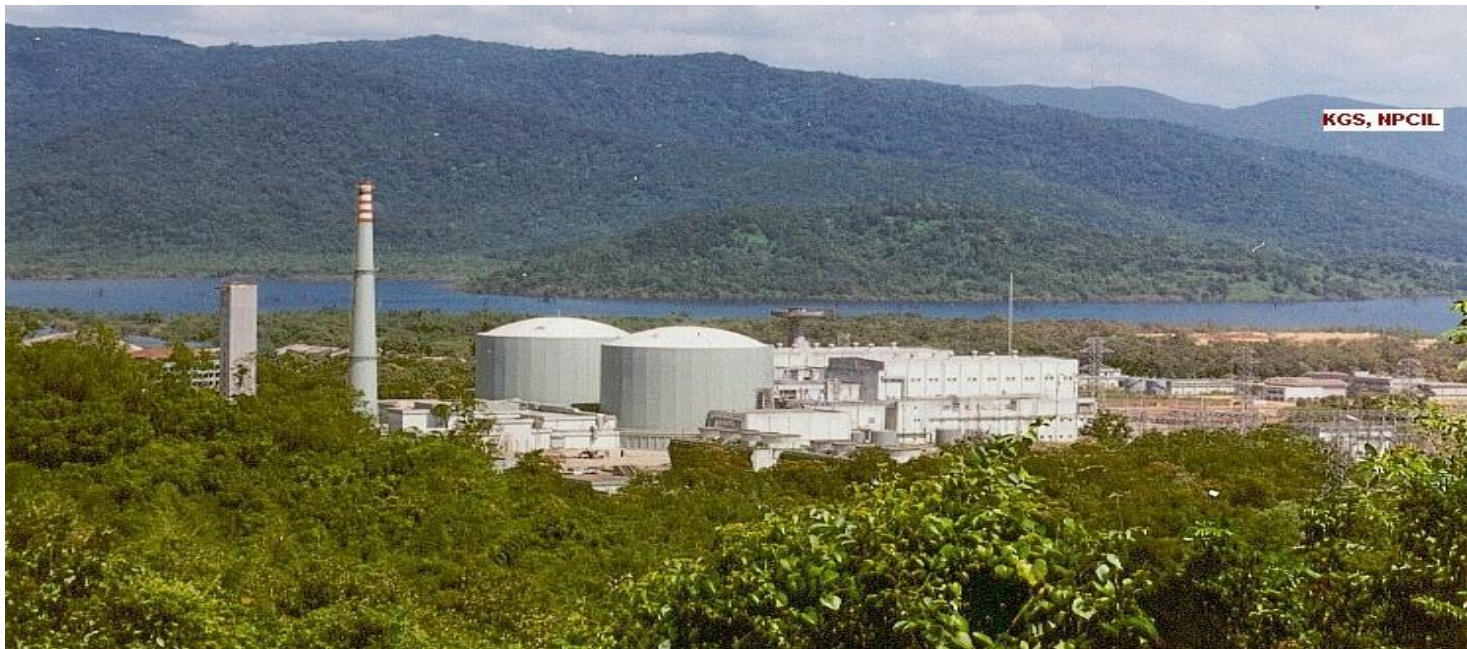
P. M. Ravi

Bhabha Atomic Research Centre, India

Indian Nuclear Power program

- Mainly CANDU type PHWRs. A few LWRs are under construction and operational.

- Tritium is one of the major constituents of liquid and gaseous effluents.

- Located in seven sites with very different climatic conditions.

- Routine Environmental survey carried out by Environmental Survey Labs (ESL)

- Strict compliance to regulatory limits.

Public Dose from tritium

- Public dose from tritium during routine release is a small fraction of that from natural sources (1-3 µSv/y).

- Dose from OBT during routine release is estimated to be less than 0.02 µSv/y.

    - P.M.Ravi, et al, Jl.Nuclear Science and Technology, Sup 5,p 635 (2008).

- Design features ensures safety of the plants.

- A systematic emergency preparedness program exists to mitigate consequences of an accident.

Intervention Levels for various countermeasures

Counter measure	Intervention Levels (mSv)	
	Lower	Upper
Domain-1		
Sheltering	20	100
Evacuation	100	500
Domain-2		
Sheltering	5	20
Domain-3		
Control on food stuff	1	5

EMRAS hypothetical exercise indicated that a release of the order of 10^{15} Bq/h can lead to public dose of 5 mSv, the intervention level for counter measures.

Studies conducted in India

- Computed wash out coefficients for different distances and for different rain fall rates.
  - V.Abrol, Bulletin of Radiation Protection, <u>13</u>(1)(1990).
- The rate of movement of tritium downward in soil is maximum 0.61cm/d during rain.
  - C.K.Agarwal, etal, Bulletin of Radiation Protection, <u>13</u>(1)(1990).
- Estimated residence time of tritium in tropical plants. Three compartments with mean residence time as 2.2d, 10.0d and 44.7d in garden grass.
  - Sadarangani, et al, Bulletin of Radiation Protection, <u>13</u>(1)(1990).

Studies conducted in India

- The mean residence time of tritium and transpiration rate in a coconut palm tree is measured to be 124 hrs (5 days) and 2.2 $L.h^{-1}$ respectively.

  - K.Vasu, Bulletin of Radiation Protection, <u>13</u>(1)(1990).

- Estimated the transpiration rates of many tropical plants.

  - Selvi, et al, (IARP NC 2005) organized by IARP, at Mumbai during November 23-25, 2005.

- Site specific Air to soil Transfer Factor were found to vary from 0.15 to 0.89.

  - T.L. Ajith, etal, ICFCR-2008, Mangalore university, Mangalore, India.

Environmental modeling of tritium

- Developed a methodology for the estimation of dose to member of public due to accidental release of tritium.
  - Validated as part of EMRAS-1 (Hypothetical scenario).
- Needs refinement regarding
  - Conceptual clarity during dynamic conditions
  - Dynamicity to be imparted.
- Major uncertainty due to
  - Variability in HTO to OBT conversion factor.
  - Variability in Residence time of HTO and OBT in the plant.

Studies in Progress

- Simultaneously Estimated around the power plant
  - Air moisture HTO.
  - Soil moisture HTO
  - Plant Moisture HTO
  - A few OBT measurement
- The interpretation of results is in progress.
- Controlled experiment and aquatic environment in progress.

Tritium dynamics –Aquatic

- Estimate time required to reach steady state HTO concentration in fish.

- Estimate maximum HTO concentration in fish.

- Estimate OBT concentration as a function of time.

- To understand influence of biomatter growth.

- Arrive at SAR.

- Estimate HTO and OBT elimination rate.

Aquatic exposure data set

- About 20 fishes exposed to known tritium concentration. 5 fishes were grown in tritium free water as control. Fishes were sampled for analysis in every 3/4 days initially and once in a week after 20 days. Water quality and tritium activity measured periodically . Muscles, bones and other parts were separated. HTO and OBT estimated in muscles and other parts . Water content and organic content of the samples were also estimated.

Conclusions of fish experiment

- TFT reached steady state within 24 hours.
- Detectable amount of OBT was observed within 3 days.
- The Specific activity ratio (OBT/TFT) in muscles estimated.
- The Specific activity ratio (OBT/TFT) in other parts estimated.
- The results are under review.

Tritium dynamics -Terrestrial

HTO dynamics

- Estimate time required to reach maximum HTO concentration in plant consequent to an acute release.

- Estimate maximum HTO concentration

- Find out the influence of
  - Water content
  - Transpiration rate
  - Climatic conditions

- Arrive at an expression for time integrated HTO concentration in plant.

OBT dynamics

- Estimate OBT concentration in plant during growth.

- Find out the influence of

  - The time integrated concentration of TFT in the plant during its growth.

  - Bio mass growth rate in the plant.

  - Concentration of exchangeable hydrogen present in dry matter of plant (Edible and non edible).

- Arrive at an HTO to OBT conversion rate.

Proposed Environmental Chamber Experiment

Proposed work program-Stage-1

- Different types of plants will be grown in pots in the environmental chamber in controlled conditions.
- Water and nutrients will be provided as per standard practices of agriculture.
- Samples of plant parts will be collected at various stages of growth.
  - Increase in water content will be estimated.
  - Biomass growth rate will be estimated.
  - Organic compounds in dry biomass will be characterized and estimated.
  - Content of non exchangeable (carbon bound) and exchangeable hydrogen atoms will be estimated.

Proposed work program- Stage-2

- Plants will be exposed to known tritium concentration for known period of time in environmental chamber.
- Light intensity, humidity and temperature will be controlled.
- Plant body will be sampled at various stages of growth.
  - Specific activity of tritium in TFT pool in the plants will be estimated .
  - Specific activity of tritium in OBT pool will be estimated.
- TFT growth rate correlated with water content and transpiration rate in the plant.
- Time integrated TFT concentration in plant during growth period will be estimated.
- OBT concentration in various growth stages will be estimated.
- A normalized TFT to OBT conversion rate
  - per unit time per unit bio mass growth
  - Per unit time per unit exchangeable hydrogen concentration
    will be evaluated.

Uncertainties

- **Arises from**
  - **Variability in size , water content , transpiration rate, associated water dynamics, etc.**
  - **Variability in growth rate of biomass and biomass constituents**
  - **Variability in utility –Human consumption, animal consumption, etc**
- **Segregate plants based on water content, transpiration rate and biomass growth.**

Segregate the trees based on water content

Sr No.	Water content	Time required to reach max. HTO conc.	Observed max. HTO conc. In plant
1	<1 ml		
2	1-100 ml		
3	100 ml -1 litre		
4	1 litre – 10 litre		
5	10 litre -100 litre		
6	100 litre - 1000litre		

Segregate trees based on biomass growth rate

Sr No.		OBT conversion rate (Edible)			OBT conversion rate (Non edible /forage)		
	Growth rate	Day	Night	Mean	Day	Night	Mean
1	< 1g per month						
2	1-10g per month						
3	10-100 g per month						
4	100-1000 g per month						
5	>1000 g per month						

Support required

- **An OBT standard to validate the measurement.**

- **Test our experimental data in standard models.**

THANK YOU FOR YOUR KIND ATTENTION