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# Estimation of Tissue Free Water Tritium (TFWT) and Organically Bound Tritium (OBT) in Terrestrial Samples around Kakrapar Atomic Power Station in India

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***Abstract:***
*Tritium ($H^3$) is one of the constituents of liquid and gaseous effluents from nuclear power plants. Tritium released to the environment gets incorporated into exposed plants mainly in two chemical forms namely Tissue Free Water Tritium (TFWT) and Organically Bound Tritium(OBT).The distribution of tritium in the environment depends on the environmental conditions and type of plant. In this paper the TFWT and OBT estimations were carried out from different terrestrial samples of KAPS environment. TFWT was extracted by using distillation method and OBT was estimated along with the hydrogen present in dry matter using sample oxidiser. Tritium activity was measured by Tricarb 3170 TR/SL Model. All the samples showed TFWT and OBT activities Below Detectable Level (BDL) which proves that even though the KAPS is commercially operational since 1993, the impact on the KAPS environment is statistically insignificant.*

***Keywords***: *OBT, PHWR, TFWT, Tritium*

## 1. Introduction

Tritium is one of the constituents of effluent streams of Pressurised Heavy Water Reactors (PHWR's), which is presently operational at Kakarpar Atomic Power Station (KAPS), India. During normal operating conditions, the release of radio nuclides to the environments from power plants generally found below the limits prescribed by the regulatory body. The tritium release from a PHWR type reactor is in the form of tritiated water (HTO) which mixes with water in atmospheric, terrestrial and aquatic environment. Tritium gets incorporated into soil water through wet and dry deposition processes. In the biota, tritium undergoes complex chemical reactions and gets partly incorporated in bio organic compounds [1]. Tritium can get incorporated in plants through different pathways via photosynthesis, root uptake and tritiated methane present in the atmosphere globally [2]. It is incorporated into the organic matter of plants as tissue-free water tritium (TFWT) and also as a organically-bound tritium (OBT) [3]. Tritium activity in plant leaves equibrilates quickly with the tritium activity in the air moisture. The radiological significance of OBT is greater than that of HTO because of its longer residence time in plants.

A systematic environmental surveillance was carried out around KAPS by Environmental Survey Laboratory, Health Physics Division, and Bhabha Atomic Research Centre to monitor the exposure received by general public due to continuous operation of KAPS.

## 2. Material and Methods

*2.1. Site description*

The study was carried out at KAPS Gujarat where two Pressurised Heavy Water Reactors (PHWRs) having capacity of each 220 MWe are operational since 1993. Two units of PHWR's (700 MWe) are under advance stage of construction. This is an inland site situated on the southern bank of Moticher Lake, which is about 85 km away from Surat, Gujarat state, India (Latitude-21$^o$ 14' N and longitude-73$^o$ 22' E).

*2.2. Sample collection*

From the selected locations (Moticher, Kakarpar, Jamankua and Ratania), sampling location Moticher is at the distance of 1.6 km and remaing three locations (Kakarpar, Jamankua and Ratania) are at 1.6 to 5 Km from KAPS. Terrestrial samples such as soil, rice, brinjal, papaya and sugarcane were collected monthly. One kg of fresh sample was collected and brought to the laboratory. Each sample was cut (about 50-100 g) into small pieces of 0.5 to 1.0 cm and transferred to a distillation flask. After distillation, 4 ml of the tissue free water (distillate) was collected and transferred in a vial containing 15 ml of the scintillator solution.

*2.3. Analysis of TFWT*

The vial containing 15 ml cocktail solution (Ultimagold LLT) and 4 ml sample solution was counted for tritium activity in a liquid scintillation analyser (Tricarb-3170 Model, PerkinElmer make). The counting efficiency of the liquid scintillation analyser was 17% and the background was 1.5 cpm.

*2.4. Analysis of OBT*

After drying the sample, powder of the sample was made. About 0.5 to 1.0 g of the dry powder was weighed and burned into a PerkinElmer sample oxidizer (Model No. 307). The tritiated water obtained was collected in a tritium counting vial and 15 ml scintillation cocktail (Ultimagold LLT) was added to the vial and the OBT was counted in Tricarb 3170 Model. Standard methods in ESL manual were used for analysis of terrestrial samples [4]. This procedure is applicable for biological samples including vegetation, foods and tissues. The blank was also determined in sample oxidiser. The standardisation was carried out with NIST certified tritium standards. The counting efficiency of the liquid scintillation analyser was 17% and the background was 1.5 cpm.

**3. Results and Discussion**

Details as samples, locations and TFWT activities are given in table 1. All the terrestrial samples (soil, rice, brinjal, papaya and sugarcane) from four locations (Moticher, Kakarapr Ratania, and Jamankua) showed TFWT activities Below Detectable Level (BDL). The minimum detectable activity for TFWT samples for soil, rice, brinjal, papaya and sugarcane was ≤7.0(Bq/Kg), ≤8.0(Bq/Kg), ≤8.0(Bq/Kg), ≤6.0 (Bq/Kg) and ≤7.0 (Bq/Kg) of fresh weight respectively.

Table 2 shows the activities of OBT in different terrestrial samples. All the terrestrial samples from four locations (Moticher, Kakarapr, Ratania and Jamankua) showed OBT activities Below Detectable Level (BDL). The minimum detectable activity for OBT for soil, rice, brinjal, papaya and sugarcane was ≤60.0 (Bq/Kg) , ≤70.0(Bq/Kg) , ≤70.0 (Bq/Kg) , ≤60.0 (Bq/Kg), and ≤60.0 (Bq/Kg) of dry weight respectively.

The TFWT of neem leaves was found in the range of 0.02-56.56 Bq/ml in the Kalpkkam environment[5]. In the present study the TFWT was found to be BDL in all terrestrial samples. The findings of present study may be due to type of plant, stage of plant, foliar absorption and root uptake. TFWT gets eliminated from the plants by evatranspiration because of its presence as water exchangeable form. It's residence time in the plant varies from six to ten days.

The OBT levels in the neem leaves were found to be in the range of 13.4 - 89.56 Bq/ml [5]. In present study the OBT activities in all terrestrial samples were found to be BDL. The observations of the present study may be due to type of plant, stage of plant, photosynthetic rate, light intensity, water uptake, etc. thus it is not surprising that many authors observed discrepancies between OBT activities from the same location and same species [6].

The OBT concentration in the edible part of plant is highest in the generative period when the fruit grow [7]. For the estimation OBT in terrestrial samples from KAPS environment only edible part of the samples were analysed

The elimination of TFWT in the plant is faster as compared to that of OBT. This is because in the OBT is bounded to a carbon of cellular, intracellular level therefore tritium may prolong for longer time period after exposure. The elimination of OBT is through metabolic processes. Therefore OBT becomes major constituent in the plant part. Since the route through which tritium enters into the plant is complex, a detailed work on the pathways of tritium from environment to the plant is required understand the phenomenon.

The OBT activities in tomato, radish and beet at Chalk River Laboratories Site were 347 Bq/l, 549 Bq/l and 321 Bq/l respectively [8]. The power stations like Kalpkam showed TWFT and OBT activities in terrestrial samples. In terrestrial samples of KAPS environment TWFT and OBT activities were found to be BDL in all four locations.

**4. Conclusion**

A preliminary study carried out to estimate the TFWT and OBT in various terrestrial samples of Kakarapar environments showed the activities Below Detectable Level (BDL). This study proves that even though the units of KAPS are commercially operational since 1993, the impact on the KAPS environment is statistically insignificant.

| Location | No. of samples | Soil (Bq/Kg) fresh wt. | Rice (Bq/Kg) fresh wt. | Brinjal (Bq/Kg) fresh wt. | Papaya (Bq/Kg) fresh wt. | Sugarcane (Bq/Kg) fresh wt. |
|---|---|---|---|---|---|---|
| Moticher | 34 | ≤7.0 | ≤8.0 | ≤8.0 | ≤6.0 | ≤7.0 |
| Kakrapar | 34 | ≤7.0 | ≤8.0 | ≤8.0 | ≤6.0 | ≤7.0 |
| Ratanaia | 34 | ≤7.0 | ≤8.0 | ≤8.0 | ≤6.0 | ≤7.0 |
| Jamankua | 34 | ≤7.0 | ≤8.0 | ≤8.0 | ≤6.0 | ≤7.0 |

*Table 1: TFWT activities (Bq/Kg) of fresh weight in terrestrial samples*

| Location | No. of samples | Soil (Bq/Kg) dry wt | Rice (Bq/Kg) dry wt. | Brinjal (Bq/Kg) dry wt. | Papaya (Bq/Kg) dry wt. | Sugarcane (Bq/Kg) dry wt. |
|---|---|---|---|---|---|---|
| Moticher | 34 | ≤60.0 | ≤70.0 | ≤70.0 | ≤60.0 | ≤60.0 |
| Kakrapar | 34 | ≤60.0 | ≤70.0 | ≤70.0 | ≤60.0 | ≤60.0 |
| Ratanaia | 34 | ≤60.0 | ≤70.0 | ≤70.0 | ≤60.0 | ≤60.0 |
| Jamankua | 34 | ≤60.0 | ≤70.0 | ≤70.0 | ≤60.0 | ≤60.0 |

*Table 2: OBT activities (Bq/Kg) of dry weight in terrestrial samples*

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