given in Table 1. For calculating the release of radioactivity through the stacks of these TPS, it is assumed that the coal contains 30% ash and utilities have 95% fly-ash control to abate particulate pollution. It is further assumed that 15 tonnes of coal per day is required to generate 1 MWe electricity and the TPS operates for 180 days in a year, on an average. Practically all the releases from the stacks get dispersed and deposited within a circle of 80 Km radius around the utility. The total population living in these areas is estimated using average population density statistics from 1981 census for the states under consideration (4).

In considering the radiation health hazard from the operation of TPS, inhalation exposure is considered as important because of insoluble nature of fly-ash, enrichment of radionuclides in fly-ash over coal and because the radium inhaled through fly-ash would be present in higher concentrations in the lungs than in the other soft tissues. Air-borne release is thus considered as the main pathway through which the people living around coal-fired TPS are exposed to enhanced levels of natural radioactivity. The collective radiation dose commitment due to inhalation to population living in the 80 Km radius area have been estimated using the assumptions given in UNSCEAR 1977 (5) regarding average dilution factor and variation of the concentrations as a function of distance and corrections for population density. The collective effective dose commitments thus calculated for the atmospheric releases from these two TPS are given in Table 2 for lung, bone marrow and bone lining cells. It also gives total activity of ^{226}Ra and ^{228}Th released from these TPS. The collective effective dose commitments and releases of ^{40}K have not been estimated because potassium compounds are very soluble in the lung and its concentration in the body is homeostatically controlled.

Name of the TPS Capacity & Population Density	Activity Release GBq/year		Body tissue under consideration	Collective Effective Dose Commitment in Person-Sv/Year			
	^{226}Ra	^{228}Th		^{226}Ra	^{228}Th	^{228}Th	Total
Nasik	2.2	3.0	Lung	0.20	0.7	9.5	10.4
480 MWe			Bone marrow	0.0040	0.01	0.82	0.84
200/Km^2			Bone Lining cells	0.03	0.05	12.24	12.3
Neyveli	15.5	2.4	Lung	2.6	1.00	13.90	17.5
600 MWe			Bone marrow	0.05	0.02	1.19	1.26
370/Km^2			Bone Lining cells	0.39	0.08	17.8	18.3

Table 2: Estimates of collective effective dose commitment from operations of thermal power plants arising from Inhalation during the cloud passage.

Operation of nuclear power plants also releases some radioactivity to the environment. Recent cost benefit methodology calls for comparative risks from different energy sources. Hence the relative radiation risk of TPS assessed above has been compared with that of BWR type reactor at Tarapur. The estimate of collective effective dose equivalent commitment per unit power generated by BWR type reactor has been given by Hamilton (6). It is assumed in this comparison that Nasik and Neyveli TPS are operated with same power output as Boiling Water Reactors, other conditions remaining the same. The noble gas releases from Heavy Water Reactors of the type at Kota are about 5% of that for BWR, hence the dose is between 1-5% depending on the distance from the reactor and hold-up facilities provided in the reactor (7). The conversion of the collective dose commitments into collective effective dose equivalent commitment allows a better evaluation of the impact of the various radionuclides and of the various pathways. Table 3 summarizes the collective effective dose equivalent commitments resulting

from atmospheric discharges of Nasik and Neyveli TPS and similar capacity nuclear power stations operated as BWR and HWR type reactors at Tarapur and Kota, respectively. It is seen from the table that the doses from nuclear power plants are less than 10% of those from TPS type power generating stations.

Name of TPS & capacity	Person-Sv/Year		
	Actual	If operated as BWR	If operated as HWR
Nasik 480 MWe	1.72	0.15	0.0080 (Max)
Neyveli 600 MWe	2.80	0.34	0.017 (Max)

Table 3: Estimates of collective effective dose equivalent commitments from the TPS and same power plant operated as BWR or HWR.

A survey of the environmental gamma radiation dose was carried out around Nasik and Neyveli TPS and Tarapur Atomic Power Station (TAPS) and Rajasthan Atomic Power Plant (RAPP). This was done using locally fabricated gamma radiation survey meter having sensitivity of 0.1 μR/Hr. Table 4 gives the results of this survey. At the time of survey TAPS was operating at 150 MWe, RAPP at 150 MWe and Nasik and Neyveli power stations at 480 MWe and 600 MWe, respectively. Ash pond areas of TPS gave relatively higher radiation doses of 19.5 μR/hr and 20.2 μR/hr for Nasik and Neyveli TPS, respectively. The radiation doses in the environments of all the power stations were comparable and were in the range of variations of natural background doses,(Table 4).

In conclusion, the study shows that the radiation doses from TPS are comparable to those for nuclear power plants. All the doses are in the range of natural background radiation dose, the highest doses being about three times the average natural background dose of about 7 μR/hr. It is also seen that the collective effective dose equivalent commitments computed for 80 Km radius around TPS are an order of magnitude higher than those for nuclear power plant of similar size.

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REFERENCES

(1) India 1982, A reference annual, Chapter 18, Energy, Publications Divisions, Govt. of India, New Delhi, 283-302 (1982)
(2) Lalit, B.Y. and Ramachandran, T.V., Natural radioactivity in Indian food stuffs, (In) Adams, J.A.S. & Lowder, W.M. ed., Proc. of Natural Radiation Environment III, Rice University, Houston,Texas, 800-809 (1980).
(3) Mishra, U.C., Lalit, B.Y., Shukla, V.K. and Ramachandran, T.V., Standardized low level measurement methods for environmental studies, (In) Proc. of IAEA Symp. on "Methods of Low Level Counting and Spectrometry", IAEA-SM-252/66, IAEA, Vienna, 189-199 (1981).
(4) India 1982, A reference annual, Chapter 1, Land and people, Publications Division, Govt. of India, New Delhi, 1-11 (1982).
(5) UNSCEAR, Sources & Effects of Ionizing Radiation, Annex B: Natural sources of radiation, United Nations, New York, 35-114 (1977).
(6) Hamilton, L.D., IAEA Bulletin, 22, No.5/6, October, 35-77, (1980)
(7) UNSCEAR, Ionizing Radiation: Sources and Biological Effects, Annex F: Exposures resulting from nuclear power production, United Nations, New York, 249-331 (1982).

Details of Power Station & Date of Sampling	Sampling Location	Radial Distance from Centre & Direction Km	Dose Rate μR/hr	Details of Power Station & Date of Sampling	Sampling Location	Radial Distance from Centre & Direction Km	Dose Rate μR/hr
Nasik TPS	Power Stn.	-	7.0	Neyveli TPS	Power Stn.	-	9.8
480 MWe	Chemistry Lab	0.5 NE	4.5	600 MWe	Fly-ash Yard	-	11.5
Stack ht.	Coal handl-			Stack ht.	Entrance		
80 M	ing area	1.0 S	12.0	20M, 60M	Gate	0.5 NE	8.2
June 1982	River Bank	1.0 NE	20.1	July 1983	Water treat-		
	Ash Pond-II	1.2 N	11.8		ment lab.	0.5 W	8.6
	Pump House	1.5 N	10.5		Ash Pond-I	1.0 E	16.9
	Guest House	2.0 SW	6.5		Ash Pond-II	1.5 SW	20.2
	Location at	2.5 S	12.6		High dump		
	Ash Pond-II	3.0 NE	19.5		yard	1.5 E	12.0
	Nasik Rly.				Ash Pond-I	2 WS	16.7
	Station	6.0 SW	7.0		Guest House	3.0 E	13.5
					C.T.Office	7.0 NE	7.4
Tarapur BWR				Kota HWR			
150 MWe	Power Stn.	-	18.6	150 MWe	RAC Campus	-	19.3
Stack ht.	Security			Stack ht.	Phase I		
110 M	Gate	1.6 SE	18.5	100 M	Colony	2 NE	21.9
Aug.1983	Kuden	3 NEE	9.4	Sept.1983	RPS Colony	6 W	20.8
	TAPS Colony	4 SE	8.8		Phase II		
	BARC				Colony	7 N	20.8
	Quarters	5 E	8.9				
	Chinchni	5 NEE	8.6				
	Kurgaon	8 E	7.0				
	Boisar	12 SE	6.8				

Table 4: Typical radiation doses observed at some power plants in India.