RADIOLOGICAL EFFECTS OF YATAGAN COAL-FIRED POWER PLANT

Barlas F., Büke T.
Mugla University, Muğla, Turkey

UZ0703381

ABSTRACT

Radiation dose calculations and limit radiation dose calculations have been carried out by the code CAP88-PC around the Yatagan coal-fired power plant environment by using the result of previous studies about maximum measured gross alpha activity in the flying ash samples as radioactive sources.

A modified Gaussian plume equation is used to estimate the average dispersion of radionuclides released from up to six emitting sources. The sources may be either elevated stacks or uniform area sources. Assessments are done for a circular grid of distances and directions for a radius up to 80 kilometers, 16 wind sectors and 20 mesh distances around the facility in calculations.

The limit doses obtained from the calculations and their radiological effects have been interpreted. Finally the effects of various radionuclides have been carried out and their results have been compared with each other.

INTRODUCTION

In recent years, to meet the national electrical energy need, coal-fired power plants have been established in increasing number, in our country. One of the earliest coal-fired power plants in Turkey, Yatagan with capacity of 3×210 MW is located in Mugla province to produce electricity since an important part of lignite reserve of Turkey can be found in this region [1]. Lignite, like most materials found in nature, contains trace quantities of naturally occurring radionuclides. Lignite in Mugla province contains some uranium as all lignite does. On the other hand lignite with low quality contains high uranium concentration.

In the production process of electrical power, lignite is burned, uranium and certain radioactive elements become concentrated and enriched in the ash. While the well-burned ash goes to the plant chimney, the other called slag ashen, is not burned perfectly and is dropping in the furnace chamber floor. The escaped flaying ash is released to the atmosphere, depending on the efficiency of the plants emission control equipment. The major potential path way which might result in increased radiation doses to humans from coal-fired power plant emission are inhalation flying ash, ingestion of food grown in contaminated soil or direct radiation exposure from the increased deposited radioactivity [2,3].

In this study, radiation dose calculations and limit radiation dose calculations have been carried out by the code CAP88-PC around the Yatagan coal-fired power plant (YPP) environment by using the results of previous studies about maximum measured gross alpha activity in the flying ash samples as radioactive sources[4,5]. A modified Gaussian plume equation is used to estimate the average dispersion of radionuclides released from up to six emitting sources. The sources may be either elevated stacks or uniform area sources. Pasquill conditions were based on the local weather conditions and topography. The meteorological data obtained for Yatagan from Turkish State Meteorological Services [6] were processed to find wind frequencies. The population distribution around the plant is obtained from Turkish State Institute of Statistics [7] according to the last census. Assessments are done for a circular grid of distances and directions for a radius up to 80 kilometers, 16 wind sectors and 20 mesh distances around the facility in calculations.

The limit doses obtained from the calculations and their radiological effects of various radionuclides have been carried out and their results have been compared with each other.

DOSE CALCULATIONS

Radiation dose and risk calculations have been carried out by the code CAP88-PC around the plant environment by using the estimated gross alpha activity in the flying ash samples as a radioactive source. The CAP88-PC (which stands for Clean Air Act Assessment Package-1988) computer model is a set of computer programs, databases and associated utility programs for estimation dose and risk from radionuclide emission to air.

It uses a modified Gaussian plume equation to estimate the average dispersion of radionuclides released from up to six sources. The sources may be either elevated stacks, such as a smoke stack, or uniform area sources, such as a pile of uranium mill tailings. Plume rise can be calculated assuming either a momentum or buoyancy-driven plume. Assessments are done for a circular grid of distances and directions with a radius of 80 kilometers around the facility.

The program computes radionuclide concentrations in air, rates of deposition on ground surfaces, concentrations in food and intake rates to people from ingestion of food produced in the assessment area. Estimates of the radionuclide concentrations in produce, leafy vegetables, milk and meat consumed by humans are made by coupling the output of the atmospheric transport models. Agricultural arrays of milk cattle, beef cattle and agricultural crop area are generated automatically, requiring the user to supply only the agricultural productivity values.

Dose and risk are estimated by combining the inhalation and ingestion intake rates, air and ground surface concentrations with the dose and risk conversion factors used in CAP88. The effective dose equivalent is calculated using the weighting factors in International Commission of Radiation Protection (ICRP) Publication 26 [8].

The calculated maximum effective dose equivalent rate around the YPP is **0.0064 mSv/y** for **653 Bq/kg** which is the maximum measured gross alpha-activity in flying ash and it is assumed that the source of the alpha-activity comes from 90% ^{238}U complex chain and 10% ^{232}Th in total [5]. This value does not any risk for public health around the plant environment [9-11].

In this study limit radiation dose values and radionuclide effects have been tried to find out for the YPP environment.

In the first part of the study it is assumed that the nuclide inventories contain the same percentage of isotopes in the nuclide release rate and it is also assumed that only alpha radioactive isotopes are considered in both complex chains. And the previous studies have been taken as a reference and the measured gross alpha-activities have been increased periodically up to the calculated maximum effective dose equivalent rate is **5mSv/y** at any point of the YPP environment.

In the second part of the study ^{232}Th concentration is ignored because of its lack amount in total also the half life of ^{232}Th is much more greater than that of ^{238}U so only the effects of ^{238}U is discussed in this part.

Plume rise is calculated by using the momentum plume model since ash emission velocity at the chimney exit is known. An average lid for the assessment area is provided as a part of the input data. The agricultural data like beef cattle density, milk cattle density and land fraction cultivated for vegetable crop and others input to the code for Yatagan to the dispersion data to estimate the uptake of emitted radionuclides into the food chain.

The meteorological data obtained from Turkish State Meteorological Service for Yatagan region is processed to find out the stability array file consists of 4 different wind frequencies, one for each of the 16 wind directions on 6 Pasquill stability categories.16 records are entered for each Pasquill stability category and wind frequencies.

The program uses a population file for dose calculations. This file contains the location description, latitude, and longitude of the facility, the number of distances and population for each distance according to 16 wind directions in counterclockwise order starting with north and 20 distances are used for each wind directions. The distances are edge points of each sector and are entered in the population file in kilometers.

The population distribution file is prepared around the plant for 20 distances of each wind direction and this file is used in dose calculation. The main input data used in radiation dose calculations are given in Table-1 [6,12,13].

CONCLUSION

In this study limit radiation dose calculations which have harmful health effects on people around YPP have been tried to obtain by using CAP88-PC computer code.

Calculated effective dose equivalent rate values for radionuclides 90 % ^{238}U, 10 % ^{232}Th around YPP environment are given in Table 2. It is seen that the maximum effective dose equivalent rate is **5.02 mSv/y** for the estimated gross alpha-activity in flying ash **515814 Bq/kg.** This activity is approximately **800 times greater** than the measured maximum reference value.

In the second part of the study the same emission has been used for calculating the effective dose equivalent rate values including only ^{238}U radionuclide and pathways effect around the YPP environment as seen in Table3. It is seen that this time the maximum effective dose equivalent rate reduces to **4.00 mSv/y.**

As a consequence Uranium and Thorium in lignite accumulated in humans may cause major hazard. Since the radioactivity in lignite can be change in depend of its quality so it is necessary and important to make radioactivity measurements in the ash samples of YPP regularly.

Table 1. Main Input data

Item	Values
Grid distances, (m)	1800, 3650, 3850, 4800, 5800, 6750 7600, 8300, 8950, 9300, 10000, 10700 11800, 12700, 13000, 14300, 15500 16300, 17200, 21000
Meteorological Data	
Annual precipitation in Yatagan, [cm/y]	52.71
Annual ambient temperature in Yatagan, [°C]	16.78
Height of lid, [m]	620
Source Data	
Source type	Stack
Number of source	1
Agricultural Data	
Beef cattle density, [#/km^2]	$1.401*10^{-2}$
Milk cattle density, [#/km^2]	$3.889*10^{-3}$
Land fraction cultivated for vegetable crops	$5.173*10^{-3}$
Other Data	
Chimney height, [m]	120
Chimney inner diameter at the exit, [m]	3.6
Ash emission velocity at the chimney exit, [m/s]	2.5
Plant loading factor	75%
Estimated gross alpha-activity in flying ash, [Bq/kg]	515814
Radionuclide list in the escaping ash	90% ^{238}U, 10% ^{232}Th
Human inhalation rate, [cm^3/hr]	$9.17x10^5$

Table 2. Effective dose equivalent rate for 90% ^{238}U and 10% ^{232}Th (**in mSv/y**) around YPP environment

Distance (km)	N	NNW	NW	WNW	W	WSW	SW	SSW	S	SSE	SE	ESE	E	ENE	NE	NNE
1.80	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.65	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00
3.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.80	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	3.10	**5.02**	0.00	0.00	1.10	0.00	0.00	0.00
5.80	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.75	0.14	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.20	0.95	0.00	0.00	0.23
7.60	0.00	0.00	0.00	1.30	0.00	0.00	1.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.20	0.00	0.00	0.00	0.00	0.29	0.00
8.95	0.00	0.00	0.64	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.30	0.00	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	2.90	1.30	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.70	0.11	0.00	0.00	0.00	0.00	0.70	0.00	0.00	1.50	0.00	0.00	0.00	0.69	0.00	0.00	0.00
11.80	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
12.70	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00
13.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.20	0.00
14.30	0.00	0.30	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.00	0.00	0.00
15.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.18	0.00
16.30	0.00	0.00	0.35	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00
17.20	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.14	0.00

Table 3. Effective dose equivalent rate for ^{238}U (**in mSv/y**) around YPP environment

Distance (km)	N	NNW	NW	WNW	W	WSW	SW	SSW	S	SSE	SE	ESE	E	ENE	NE	NNE
1.80	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.65	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00
3.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.80	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	2.40	**4.00**	0.00	0.00	0.87	0.00	0.00	0.00
5.80	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.75	0.12	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.76	0.00	0.00	0.19
7.60	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.24	0.00
8.95	0.00	0.00	0.52	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.30	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.00	2.30	1.10	0.00	0.00	0.00	0.00	0.00
10.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10.70	0.096	0.00	0.00	0.00	0.00	0.56	0.00	0.00	1.20	0.00	0.00	0.00	0.56	0.00	0.00	0.00
11.80	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00
12.70	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00
13.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.17	0.00
14.30	0.00	0.25	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00
15.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.15	0.00
16.30	0.00	0.00	0.29	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00
17.20	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.12	0.00

REFERENCES

1. Aslan, M.: "A Typical Example of the Discussion About the Environmental Impacts of Coal-Fired Thermal Power Plant in Turkey: Yatagan Thermal Power Plant Experience", Energy Production from Coal, Workshop on environment and public, (30 May - 1-June 1995).
2. "Measurement Dedection and Control of Environmental Pollutants", IAEA, Proceedings of a symposium, Vienna, (1976).
3. Eral, M.: "Determination of uranium in ash-wasted from a thermal power plant and effect of them on the environment", Proceedings of Environment-87 Symposium, Izmir, Turkey, (1987), p.E-1.

4. Parks, B.; Chaki, S. P. E.: "CAP88-PC Version 2.0 Updated User's Guide", EPA 402-R-00-004, 2000.
5. Büke, T.: "Dose assessment around the Yatagan coal-fired power plant due to measured gross alpha radioactivity levels in flying ash" *Journal of Radioanalytical and Nuclear Chemistry*, 256, 2 (2003) 323-328
6. Annual Meteorological Conditions in Yatagan, Turkish State Meteorological Service, Ankara, Turkey, 2000.
7. Population by District, Subdistrict and Villages for Mugla, Republic of Turkey, Prime Ministry State Institute Statistics, Ankara, Turkey, 1997, p.8.
8. "Recommendations of the International Commission on Radiological Protection", ICRP Publication 26, Pergamon Press, (1977).
9. "International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources", IAEA Safety Series No. 115, 21 March 1996
10. ICRP Publication 72: "Age-dependent Doses to the Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Coefficients", Annals of the ICRP Vol. 26/1, (1996).
11. ICRP Publication 82: "Protection of the Public in Situations of Prolonged Radiation Exposure", Annals of the ICRP Vol. 29/1-2, (2000).
12. Selçuk, N.; Atımtay, A.; Uslu, O.; Cirik, Ş.; Vurdu, H.; Tuncel, G.; Kaya, Z.; Evirgen, M.; Yurteri, C.: Scientific Committee Report for Kemerkoy Thermal Power Plant, Ankara, Turkey, 1995, p.9.
13. Technical Report for Yatagan Power Plant, Yatagan Power Plant Administration Office, Mugla, Turkey, 1998.

UZ0703382

RESEARCH OF AN ELEMENT EXCHANGE IN SYSTEM "SOIL - WATER" BY THE ACTIVATION ANALYSIS METHOD

Zhumamuratov M.A., Zhumamuratov A., Khatamov Sh., Osinskaya N.S., Rakhmanova T.P., Suvanov M.
Institute of Nuclear Physics, Tashkent, Uzbekistan

Universal salinity of soil in Aral-zone, the adverse ameliorative condition of existing irrigating systems strongly affects quality of irrigation waters. On the other hand questions of washing salted soil in the certain degree demand studying dynamics of change of element structure soil at interaction with waters.

Therefore we have studied dynamics of change more than 12 chemical elements in soils a various degree salinity (soil are selected in Republic Karakalpakstan) at washing with distilled water in laboratory conditions and in natural conditions (in field experiences) at showering of soil with irrigational channels water for an establishment of a mobile part.

For an establishment of the dissolved part of chemical elements in soils prepared a series parallel sheds on 500 g (2-3 repeatability). Then 2-3 parallel sheds mixed with distilled water in volume on 500 ml. Through the certain time intervals the received mix has filtered through a filtering paper.