Journal of Environmental Radioactivity 132 (2014) 89–93

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Assessment of soil contamination by ^{210}Po and ^{210}Pb around heavy oil and natural gas fired power plants

M.S. Al-Masri*, Kh. Haddad, A.W. Doubal, I. Awad, Y. Al-Khatib

Department of Protection and Safety, Atomic Energy Commission of Syria, Damascus, P. O. Box 6091, Syrian Arab Republic

ARTICLE INFO

Article history:
Received 13 August 2013
Received in revised form
5 December 2013
Accepted 29 January 2014
Available online 4 March 2014

Keywords:
Polonium-210
Lead-210
Natural gas
Thermal power plants
Syria

ABSTRACT

Soil contamination by ^{210}Pb and ^{210}Po around heavy oil and natural gas power plants has been investigated; fly and bottom ash containing enhanced levels of ^{210}Pb and ^{210}Po were found to be the main source of surface soil contamination. The results showed that ^{210}Pb and ^{210}Po in fly-ash (economizer, superheater) is highly enriched with ^{210}Pb and ^{210}Po, while bottom-ash (boiler) is depleted. The highest ^{210}Pb and ^{210}Po activity concentrations were found to be in economizer ash, whereas the lowest activity concentration was in the recirculator ash. On the other hand, ^{210}Pb and ^{210}Po activity concentrations in soil samples were found to be higher inside the plant site area than those samples collected from surrounding areas. The highest levels were found in the vicinity of Mhardeh and Tishreen power plants; both plants are operated by heavy oil and natural fuels, while the lowest values were found to be in those samples collected from Nasrieh power plant, which is only operated by one type of fuel, viz. natural gas. In addition, the levels of surface soil contamination have decreased as the distance from the power plant site center increased.

1. Introduction

Combustion of different types of fossil fuel such as coal, lignite, heavy oil, diesel and natural gas for electricity production in thermal power plants (TPPs) produces a complex mixture of pollutants in the atmosphere including SO_x, NO_x, CO, acid gases, and organic compounds. Solid wastes such as fly and bottom ash represent also a serious environmental problem (Agrawal et al., 2010). Bottom and fly ash contain enhanced levels of naturally occurring radionuclides (Al-Masri and Haddad, 2012; Mishra, 2004; Bem et al., 2002; Al-Saleh and Al-Harshan, 2008; IAEA, 2003; Papastefanou, 2008; Parami et al., 2010; Mahur et al., 2008). Considering the radiation health hazards, the global interest in measuring naturally occurring radionuclides in fly and bottom ash of coal has increased.

Fly ash escaping from stacks is more concentrated with naturally occurring radionuclides and heavy toxic metals in comparison with their content in fossil fuels or surface soil. One of the main hazards can be solid fallout resulting in elevated naturally occurring radionuclides and heavy toxic element concentrations in surface soils around power plants naturally occurring radionuclides emissions in the TPP vicinity may lead to additional exposure of the local population (Bem et al., 2002; IAEA, 2003; Papastefanou, 2008). On the other hand, produced ash may be either disposed, or utilized in some applications (as building materials,…) so it is very important to study their radioactivity (IAEA, 2003). A detailed knowledge of the radiological characteristics will allow for a better assessment of the radiation exposure, both occupational and the public (Karangelos et al., 2004). However, most of the above mentioned works focused on ash produced by the coal fired power plants. There seems to be little works conducted for heavy oil and natural gas fired power plants. In addition, neither of these works has investigated the heavy oil and natural gas ash (bottom and fly) and their impact on the surface soil of the surrounding areas. In recent work (Al-Masri and Haddad, 2012), ^{210}Pb and ^{210}Po were detected in the fly and bottom ash of heavy oil and natural gas power plants operated in Syria. ^{210}Pb and ^{210}Po activity concentrations have reached 3393 and 4023 Bq kg^{-1} in fly and bottom ash, respectively. In addition, ^{210}Po and ^{210}Pb annual emissions in bottom and fly ash were determined. The present study investigates distributions of ^{210}Pb and ^{210}Po in surface soils of the vicinities of two TPPs and surrounding areas. One of the TPPs is operated by heavy oil and natural gas while the second plant is only operated by natural gas. Thus the impacts of heavy oil and natural gas fired power plants on the surrounding environment can be compared.

* Corresponding author. Tel.: +963 112132580; fax: +963 116112289.
E-mail address: prscientific3@aec.org.sy (M.S. Al-Masri).

http://dx.doi.org/10.1016/j.jenvrad.2014.01.018
0265-931X/

2. Experimental

2.1. Sampling and sample preparation

Fly ash and bottom ash samples from combustion routes, soil from plant site and surrounding areas and sediment samples from washing water disposal ponds were collected during 2011 from four heavy oil and natural gas fired thermal power plants in Syria, namely; Tishreen, Banias, Mhardeh and Nasrieh (Fig. 1). Fuel type, power of the studied plants and the annual rainfall of their sites are presented in Table 1. Samples were divided into five groups. The first group of samples (G1) was collected during shutdown maintenance period from different points along the combustion path of Tishreen power plant; namely stack, induced fan, recirculator, economizer, superheater and boiler (bottom ash) where the temperatures were 170, 350, 500, 700 and 1700 °C, respectively (Fig. 2). Samples (1 kg each) were collected using small metallic skimmer and shovel and then placed in plastic bottles.

The second group of samples (G2) consist of surface soil samples collected from the vicinities of the power plants (within the plants fences). The third group of samples (G3) consists of surface soil samples collected from villages surrounding Tishreen plant (Fig. 3), while the fourth group of samples (G4) was collected from villages surrounding Nasrieh plant (Fig. 4). Surface soil samples of each site were collected from the site center and four samples from the points located at the four directions close to power plants fences. Soil samples (1 kg each) were collected from the top 5 cm layer from an area of one square meter (composite sample).

The samples (one kg each) of the fifth group (G5) (sediments) were collected from boiler washing water ponds using plastic shovel (Table 2).

All solid samples were oven dried at 80 °C for 24 h, homogenized and stored in plastic containers.

Table 1
Fuel type, power of the studied plants and the annual rainfall of their sites.

Plant number	Plant name	Site coordinates	Site annual rainfall (mm)	Fuel	Power, MW
1	Tishreen	33°25′9.50″N 36°41′10.52″E	157	Heavy oil + natural gas	625
2	Mhardeh	35°15′49.89″N 36°35′4.37″E	369		660
3	Banias	35°10′17.69″N 35°55′37.69″E	752		710
4	Nasrieh	33°48′1.59″N 36°41′1.27″E	164	Natural gas	480

2.2. ^{210}Pb and ^{210}Po activity concentration measurement

Lead-210 was measured by low-energy gamma spectrometer (HpGe Planar model, Canberra, the relative efficiency is 10%). All samples were prepared as cylindrical shape ($r = 2.5$ cm, and h varied from 0.95 to 1.1 cm) pressed using a pressure of 40 ton cm^{-2}. The calibration source was prepared using the same procedure. The ^{210}Pb is measured directly through its gamma line 46.5 keV with an intensity of 4.0%. For self-absorption correction of the ^{210}Pb gamma-ray line, three factors were considered, namely composition, density and sample thickness. More details on this technique can be seen in Al-Masri et al. (2010). Combined uncertainty of the ^{210}Pb measurement has reached 8% depending on the ^{210}Pb activity present in the sample. The lower limit of detection of the method used was 8 Bq kg^{-1} dry wt.

Polonium-210 was determined using alpha spectrometry where each solid sample (0.2 g) was spiked with a known amount of ^{208}Po (0.2 Bq) as a yield tracer. Each sample was then digested using a combination of mineral acids (nitric and hydrochloric acid) for at least 24 hr. When the solution was clear, the sample was then gently evaporated to near dryness. The residue was then dissolved

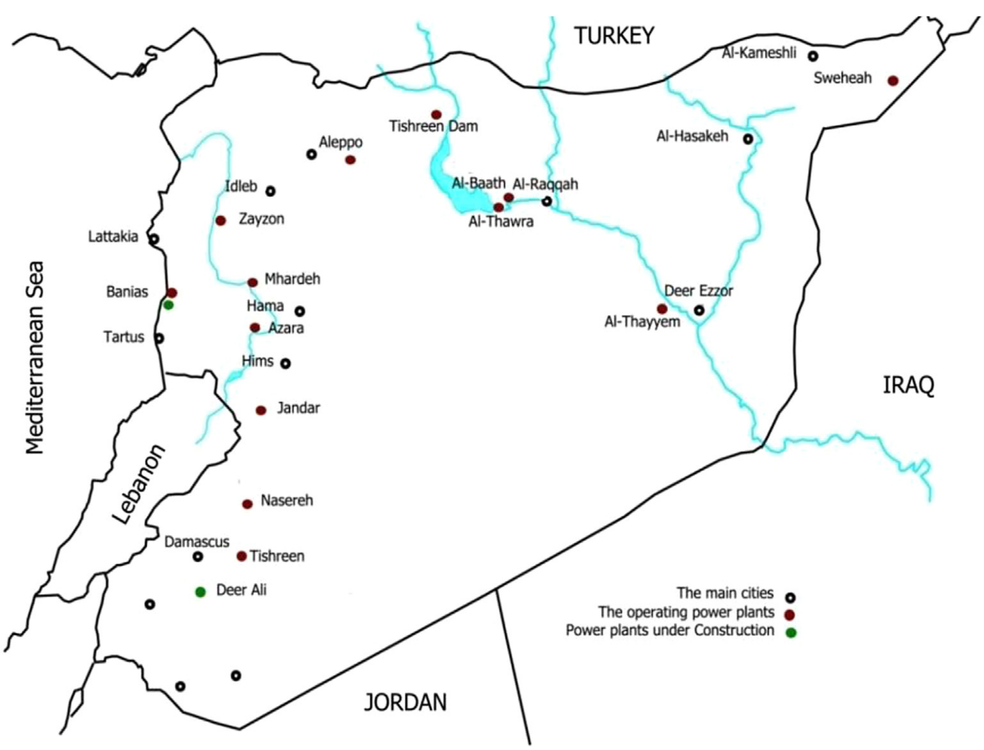

Fig. 1. Distribution of Syrian power plants.