Assessment of radioecological situation of a site contaminated by technologically enhanced natural radioactivity in Croatia

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The paper deals with radioactivity contamination originating from the coal fired power plant and its waste dumps located in a bay of the Adriatic which is due to geographical characteristics sensitive to any kind of pollution including radioactivity. Investigations of coal used in regular plant operation and of solid incombustible ash and slag showed increased concentrations of natural radioactivity which may cause general environmental contamination of the bay as well as contamination of the marine environment of this part of Croatian Adriatic. There are two coal slag and ash piles, one of them was closed and covered by soil and the other is a still operating pile. The location of both piles presents a considerable environmental problem: situated close to the seaside, slag and ash are accumulating in the littoral zone and, in the case of operating pile, are being filled up directly into the sea. The aim of this study was to determine the radioactivity level at the ash and slag deposits and to assess the risk of increased radioactivity for the inhabitants of the nearby urban area, for the plant workers and general environment of the bay including the marine environment of this part of the Croatian Adriatic.

Introduction

Electrical power requirements will necessitate the doubling of the present generating capacities in the future. As a result, environmental discharges associated with coal power industry will considerably increase and enlarge the problem of general environmental pollution that falls into a broad category of technologically enhanced natural radioactivity.1-3

The production of electric energy is always bound to the emission of several pollutants into the environment leading to possible atmospheric pollution, site contamination, due to storage of large quantities of ash and slag having increased radioactivity levels, and contamination of the immediate human environment.2-5

The study conducted by the Radiation Protection Unit, Institute for Medical Research and Occupational Health, Zagreb, aimed to determine radioactive contamination originating from the coal fired power plant and its waste dumps located in a bay of the Adriatic which is due to geographical characteristics sensitive to any kind of pollution. Investigations of coal used in regular plant operation and of solid incombustible ash and slag showed increased natural radioactivity levels which may cause general environmental contamination of the bay as well as of the marine environment of this part of the Croatian Adriatic.6-8 Radioactivity level at the ash and slag deposit sites and associated environmental risk should be determined in order to achieve a disposal system that will meet the regulatory or desired environmental protection requirements, if necessary.

In the paper special emphasis was given to the location of the plant in proximity of the urban area and possible risk to the inhabitants; the risk from increased radioactivity to the plant workers and to a direct contact of ash and slag with the sea water and possible detrimental effect of increased radioactivity on marine ecosystem and sea bioindicator organisms.

Description of the area

There are two coal slag and ash dumps with increased radioactivity, generated by the coal fired power plant located some 5 km northwest of an urban area with a population of 250,000 inhabitants. One of them (surface dimension 10000 m2), is the older (pile 1). It was closed and covered by soil (soil depth is about 0.5 m), fairly organized and periodically controlled. The average depth of accumulated material is about 1 m. The other one is a still operating pile (pile 2), also located indoor the facility area but it has not been satisfactorily monitored. The pile 2 is partly attached to the site of pile 1. It should be mentioned that deposited material from pile 2 has been partly dumped into the sea. Unlike pile 1, the slag accumulating at pile 2 originates completely from the facility's energy-producing plant. The pile contains slag and ash that have remained after burning of coal mined at locations with enhanced natural radioactivity, which has been preferred in the past few years.9,10 The location of both piles presents a remarkable environmental problem; situated close to the seaside, slag and ash are disposed in the littoral zone and, in the case of the operating pile (pile 2), are being filled up directly into the sea.

Experimental

Investigations of radioactive contamination were based on measurements performed in the field and in laboratory. In situ gamma-spectrometry was carried out using a HPGe Ortec detector (resolution 1.74 keV on
1.33 MeV $^{60}$Co, relative efficiency 21.6%), and included several measuring sites in and around the plant. Measurement time was 1000 seconds.

The sampling included ash and slag from the operating pile (pile 2), sea water and sea bioindicators. Solid samples were dried at 105 °C to constant weight and packed. The samples of mussels were dried at 105 °C and ashed at 450 °C.

In the laboratory the collected samples of ash and slag were analysed by gamma-spectrometry using a Ge(Li) ORTEC detector (resolution 1.78 keV on 1.33 MeV $^{60}$Co, relative efficiency 16.8%) with a 4096 channel analyser and a personal computer. All samples were measured in a 1-l Marinelli beaker with a measurement time of 80,000 seconds.

Liquid sea water samples were analysed radiochemically: Barium carrier is added to the water sample (250 ml) and the radium is coprecipitated with barium sulphate from a solution containing ethylenediamine tetracacetate. The precipitate is converted to carbonate and dissolved in nitric acid. Radium daughter products are extracted from this solution into thenoyltrifluoracetone. Barium sulphate is reprecipitated, weighed for determination of carrier recovery, and the total alpha-activity of radium is counted. In all the samples $^{226}$Ra was determined after radiochemical separation by alpha-spectrometric measurements using an ORTEC Si(Li) surface barrier detector. The counting time for each measurement was 60,000 seconds or longer.

Results and discussion

In situ gamma-spectrometry involved several measuring sites at the older pile covered by soil (pile 1), at the operating ash and slag deposit (pile 2), as well as at several locations around the plant. Measurement showed the presence of natural radionuclides of uranium and thorium decay series and $^{40}$K. Corresponding contribution of measured radionuclides to the absorbed dose rate was calculated for each location.

In order to determine the effect exercised to the environment by pile 1 in situ gamma-spectrometry were carried out at several measuring sites. The contribution of measured radionuclides (the members of uranium and thorium decay series, and $^{40}$K) to the absorbed dose rate was calculated for each location. Figure 1 shows the absorbed dose rate for the members of uranium and thorium decay series, and $^{40}$K measured at pile 1.