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Modeling air concentrations and risk of carcinogens and co–carcinogens in Gibraltar and source apportionment of nearby industrial facilities

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ABSTRACT

Airborne exposures of carcinogenic and co–carcinogenic pollutants, emitted from industries and various diffuse sources in a 10 km radius of Gibraltar, were calculated at the west side of the Rock of Gibraltar facing the Bay. 2005 and 2008 industrial annual emission rates reported to E–PRTR and 2005 municipal diffuse annual emission rates were entered in OML–Multi, a multi–source version of an atmospheric Gaussian plume local scale dispersion model. The model results reveal that carcinogens PAH, represented by benzo[*a*]pyrene (BaP), arsenic and nickel, and potentially chromium are the priority pollutants with respect to human cancer risk and that the contribution from industrial sources on the Spanish coastal area exceeds that from the diffuse sources from adjacent Spanish municipalities. There is a decrease in annual mean air concentrations from industrial emissions between the years 2005 and 2008. The assessment of contribution to the Gibraltar air concentrations of the priority pollutants from industrial sources shows that refinery CEPSA, chemical industry Petresa and petroleum industry Lubricantes del Sur are significant for nickel. Chemical industry Interquisa is significant for PAHs with a notable decrease in PAH emissions from 2006 to 2007, whereas the contribution from CEPSA is more constant. For arsenic only CEPSA shows a continuous trend and contributes to the 2008 air concentration together with sewerage Edar de la Linea de la Concepcion. CEPSA and metal industry Acerinox contribute the most to the chromium air concentrations. NO_2/NO_x is the most critical co–carcinogen and electricity plant Central Termica Los Barrios, CEPSA, electricity plant Generacion Electrica Peninsular and electricity plant Cogeneracion de Interquisa are the most significant contributors to the air concentrations in Gibraltar. Pollutant contributions from CEPSA flaring, ship traffic in the Bay and Strait, local road traffic and local diesel generators are currently un–quantified.

Keywords: *Air quality, modeling, carcinogens, industrial emissions, human risk*

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1. Introduction

The global burden of cancer is increasing, especially in the developed world where one of two men and one of three women will be diagnosed with cancer during their life time, for one of three of these women the diagnosis will be breast cancer. Annually, around 10 million people worldwide will be diagnosed with cancer and a total of 28 million people are currently cancer patients. Cancer etiology is complex, multi–causal, there can be up to decades between exposures and effects and the actual diagnosis. The cancer incidence rate increases exponentially with age. The World Health Organization (WHO) estimates that the worldwide cancer rates are set to increase by as much as 50% within a decade unless further preventive measures are put into practice. Preventive measures could include reduction in the involuntary exposure to environmental contaminants. According to the European Environment and Health Action Plan 2004–2010 it is estimated that each year thousands of city dwellers across the EU die prematurely due to air pollution and that one–sixth of the total burden of death and disease in European children can be attributed to environmental factors. The role of environmental parameters in the societal cancer burden is currently estimated to be approximately 5%. However, some 40% of the total cancer burden is still unaccounted for, so the contribution could be larger than 5% (WHO, 2013).

In 2010 the Danish Centre for Environment and Energy (DCE) at the University of Aarhus in Denmark conducted a study for the Government of Gibraltar to investigate the airborne exposure of carcinogens and co–carcinogens to the Gibraltar population from nearby industrial facilities and diffuse sources in the adjacent municipalities. Gibraltar implements all the EU environmental standards and measures, and they hence also implement the aims of EU Thematic Strategy on Air Pollution. Gibraltar is in compliance with the DIR 2008/50/EC in terms of reducing the exposures to hazardous air pollutants here under particulate matter, PAHs and heavy metals to achieve the health improvements laid out in the EU Thematic Strategy on Air Pollution (EC, 2013). Although having intense local road traffic and ships harboring and bunkering in the bay the main concern among the Gibraltarian government and population was directed towards the intensively industrialized area on the Spanish coast some 5 km north of the centre of Gibraltar. The scope of the tender was thus on airborne organic pollutants and heavy metals originating from industries such as the Compania Espanola de Petroleos S.A. (CEPSA) refinery and the metal industry Acerinox.

To be able to act upon the concern in a scientifically reliable and accurate way there are a number of issues that must be considered; first of all the pressure, or emission rates, from industries on the surrounding environment must be established. Industries are obliged to report emissions of harmful chemicals to various national and international bodies, e.g. on an international scale Persistent Organic Pollutants (POP) and heavy metal emissions are under the existing reporting obligations of the

Convention on Long–Range Transboundary Air Pollution (CLRTAP) and the EU requires that certain industries must report the facilities environmental pressure to the European Pollutant Release and Transfer Register (E–PRTR). The E–PRTR is the most comprehensive and readily accessible register for industrial emissions on an EU scale and is designed to provide information to citizens, industries, scientists, insurance companies, local authorities, non–governmental organizations and other decision–makers on the state and trends of the environment in relation to social, economic and health issues as well as the general raising of awareness of the environmental implications put on the environment and humans by industrial activities (E–PRTR, 2010a).

Emission rates are introduced in atmospheric dispersion models to predict environmental concentrations at a target site. The choice of model follows the criteria of being accurate, transparent and reliable and must have a complexity that reflects the actual problem; simple models may have high model uncertainty and more complex models may introduce high input parameter uncertainty. It is essential to select an exposure model that represents the actual site and tidal scale and the input in terms of e.g. meteorological data in a realistic manner. Furthermore, model results must be evaluated against air monitoring data sampled on–site in order to ensure an accurate simulation of the pollutant fate and occurrence.

A number of cities where the combination of rapid growth, dirty fuels, and polluting technologies are overwhelming the capacities to control air pollution, source apportionment techniques offer policymakers practical tools for identifying and quantifying the different sources of air pollution, and thereby increasing the ability to put in place effective policy measures to reduce air pollution to acceptable levels. Source apportionment aims to explain the chemical composition of contributions from different sources. In doing so, source apportionment quantifies the relative contributions of these different sources.

The aim of the study was to quantify the contribution from industrial sources located in the bay area and adjacent Spanish municipalities to airborne carcinogenic and co–carcinogenic pollutant concentrations in the ambient air in Gibraltar. Exposure modeling and source apportionment identified significant polluters and to evaluate the precision of model results a comparison with concentration levels, measured at a sampling station at the centre of the west side of the rock of Gibraltar facing the bay area, will be done. Furthermore, calculated and measured concentrations were compared with other EU countries and cities and assessed relative to air quality values and cancer threshold values. The study comprises compilation of reported annual emission rates for relevant industries and pollutants, set–up of local air model and simulation of annual mean concentrations in air in the centre of Gibraltar.

2. Method and Data

2.1. Location

Gibraltar is located on the southern end of the Iberian Peninsula at the entrance of the Mediterranean. Its territory covers 6 843 km^2 and shares a 1.2 km land border with Spain. The shoreline measures 12 km in length. There are two coasts of Gibraltar; the lesser populated East Side and the Westside, where the vast majority of the population of almost 30 000 lives (Figure 1). The two coasts are divided by the 426 m high Rock of Gibraltar, which can cause extreme wind conditions and significant differences in pollutant exposure concentrations between the east and the west sides (Cook et al., 1978).

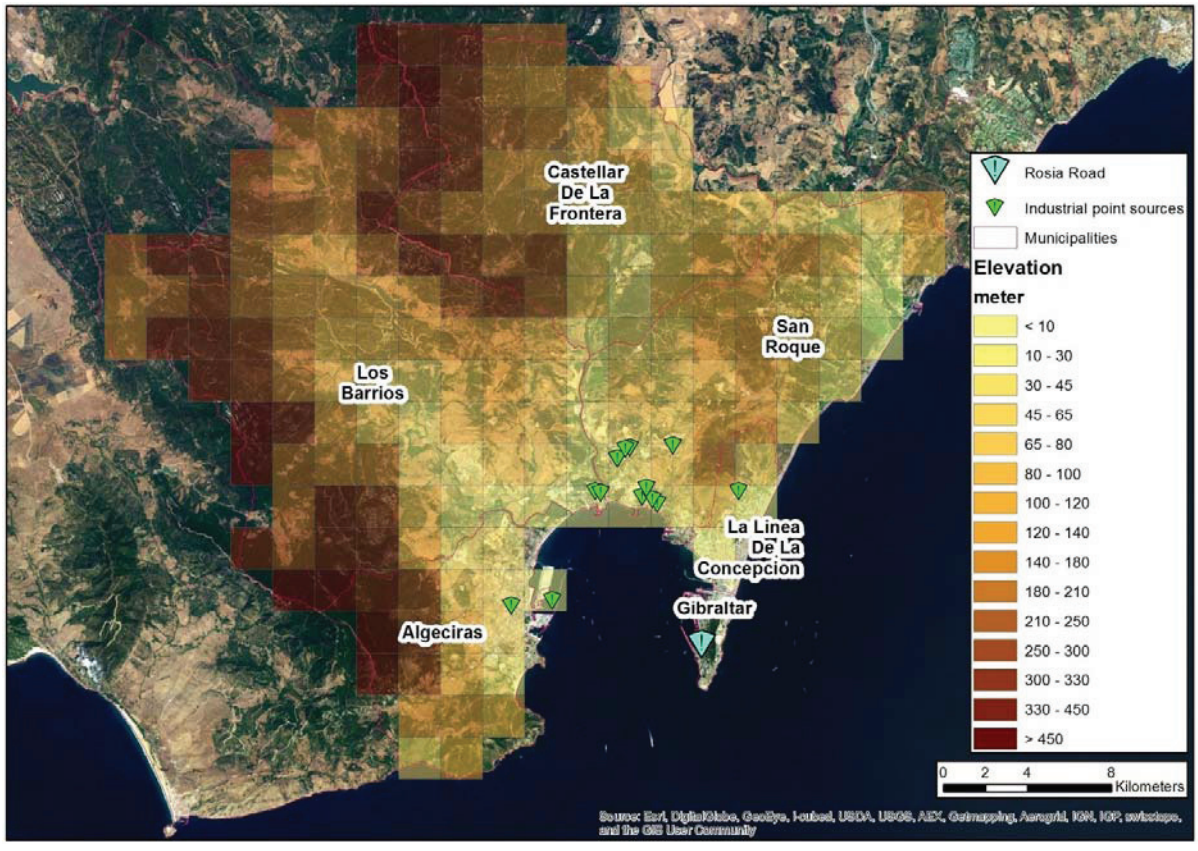

Figure 1. *Industrial point sources in Bay Area and five most adjacent municipalities with evenly distributed emission rates in each municipality. 2x2 km^2 grid cells are represented by grid points of the south-west corner.*