ELSEVIER

Desalination 177 (2005) 15–29

DESALINATION

www.elsevier.com/locate/desal

Stack emissions from desalination plants: a parametric sensitivity analysis for exposure assessment

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Received 20 January 2004; accepted 24 November 2004

Abstract

The desalination market has been continuously growing to augment conventional water resources in arid and semi-arid regions that are experiencing population growth, improvements in life-style, increased economic activity and increased contamination of existing water supplies. The introduction of desalination plants is inevitably associated with several potential environmental impacts including potential air pollution. The present study focuses on qualifying air emissions resulting from desalination plants and their potential impacts using a case study approach for an existing combined power generation and water distillation plant. The Industrial Source Complex (ISC) air dispersion model was adopted to assess sulfur dioxide concentrations at sensitive receptors under worst case meteorological conditions and full load operation for both plants. A parametric sensitivity analysis showed that receptors are exposed to concentrations exceeding international standards under most scenarios necessitating mitigation measures which were defined.

Keywords: Desalination; Sulfur dioxide emissions; Air dispersion modeling; Air pollution; ISC model

1. Introduction

Desalination is a water treatment process whereby energy is used to produce water low in total dissolved solids (TDS) through the separation of salts from saline water. As such, water sources with TDS levels exceeding the 1,000 mg/L threshold which were once thought unfit for community use, have become readily available to augment existing conventional water resources. Two main desalination techniques are relied upon, namely distillation and membrane technology. Desalination was for long considered a technology restricted for countries with affluent economies or too expensive to adopt in most arid countries that lacked large fossil fuel reserves. Recent advances in desalination technologies have decreased production costs and bridged the economic gap with conventional water sources that

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0011-9164/05/$– See front matter
doi:10.1016/j.desal.2004.11.014

are showing on their part an increasing trend in their associated costs. For this reason, the desalination industry is receiving the attention and acceptance of several arid and semi-arid countries that are in need of augmenting their available water resources to alleviate the socio-economic burdens associated with water scarcity. Nevertheless, the introduction of desalination plants into an area is linked with several potential environmental impacts including air pollution associated with energy requirements to achieve the separation of fresh water from the saline feed. Predictions of air quality in urban and industrial agglomerations show that a high percentage of atmospheric emissions are attributed to seawater desalination, especially multi stage flash (MSF) power cogeneration plants [1]. This is mainly due to fossil fuel combustion that is required to supply electricity and/or steam to the desalination process. Fossil fuel combustion releases various air pollutants. While reverse osmosis (RO) plants operate exclusively on electrical power and as such do no contribute directly to the gaseous emissions on site but rather to indirect emissions at the power plants supplying them with electricity, the wide use of high sulfur content fuel within dual distillation-power plants results in the release of stack gases rich in unburned carbon and sulfur oxides [2].

The objective of the present study is to quantify air emissions resulting from desalination plants and their potential impacts on exposed receptors by using sulfur dioxide (SO_2) as an indicator. For this purpose, an existing combined power generation and water distillation plant located in the Arabian Gulf was considered as a case study. The plants' operating conditions, the location of exposed receptors along with the meteorological and topographic characteristics of the area were defined and used to simulate SO_2 hourly concentration under base and worst-case scenarios. Management options were also examined to assess their effectiveness in reducing SO_2 emissions from desalination plants. The general methodology adopted in the study is presented in Fig. 1.

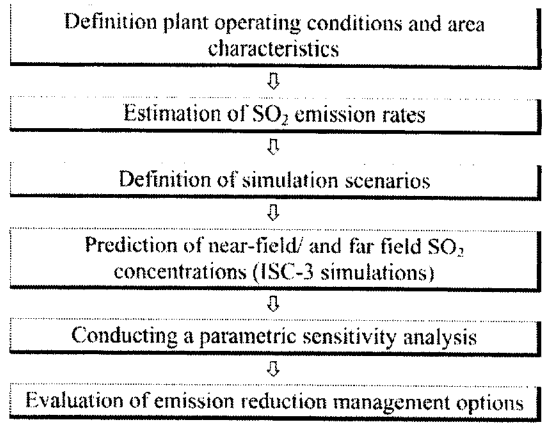

Fig. 1. Air quality assessment methodology.

2. Plant characteristics

The combined distillation–power cogeneration plant is located in the Arabian Gulf and its exact coordinates are kept anonymous at the request of the plant management. The plant is of the MSF type and was built in the early 1980's to supplement the area's increasing power and water demands. The East side of the plant has 7 power generating units each capable of producing 150 MW of power and consuming 44 ton/h of heavy fuel oil (HFO). The emissions of flue gases resulting from fuel combustion are released through two main chimney structures with 7 stacks without adequate control measures. Similarly, the West side of the plant has 8 power generating units each capable of continuously generating a maximum load of 300 MW and burning 80 ton/h of HFO. The West plant also has two main chimneys each containing four stacks that release the flue gas generated with minimal to no prior treatment provisions. Both sides of the plant are equipped to burn HFO, gas oil, crude oil, natural lean gas and natural rich gas. The operational characteristics of both sides are presented in Table 1.

2.1. Emission characterization

Pollutant emissions from the plant vary according to the fuel type used. While the plant is