

# **NOISE MAPPING, ANALYSIS AND MITIGATION OF HURGHADA AIRPORT**

**BY**

Eman Khallaaf Fathallah Khallaaf

B.SC. science (Biochemistry), Ain Shams University 1992

A Thesis Submitted in Partial Fulfillment  
of  
The Requirement for the master Degree in  
Environmental Science

Department of Environmental Basic Science  
Institute of Environmental Studies and Research  
Ain Shams University

2017

## **Approval sheet**

### NOISE MAPPING, ANALYSIS AND MITIGATION OF HURGHADA AIRPORT

By

Eman Khallaaf Fathallah

B.sc.Science (Biochemistry), Ain Shams university 1992

This Thesis Towards a Master Degree in Environmental  
Science Has Been Approved by:

Name

Signature

Prof. Dr. Hosni Ahmed Ismail

Prof. of physics, Ain Shams University

Prof. Dr. Edwar George Hanna

Native Specialized Institutes consultant and General Manager of  
Environmental Department of Civil Aviation

Prof. Dr. Mohamed Gharib El-Malky

Prof. of Environmental Geophysics, Institute of Environmental  
Studies and Research, Ain Shams University

2017

# NOISE MAPPING, ANALYSIS AND MITIGATION OF HURGHADA AIRPORT

By

Eman Khallaaf Fathallah

B.sc.Science (Biochemistry), Ain Shams university 1992

A Thesis Submitted in Partial Fulfillment of  
The Requirement for the Master Degree in  
Environmental Science

Under The Supervision of:

1- Prof. Dr. Mohamed G. El-Malky

Prof. of Environmental Geophysics, Institute of Environmental  
Studies and Research,

Ain Shams University

2- Dr. Mansour M. El-Bardisi

Lecturer, Faculty of Engineering, Ain Shams University

2017

## **Acknowledgment**

I Wish to express my sincere thanks and gratitude to Dr. Mohamed EL Malky; professor of environmental geophysics in the institute of environmental studies and research in Ain Shams University (ASU) for his help and support. Also, I wish to express my great appreciation and thankfulness to Dr. Mansour ElBardisi; Lecturer in faculty of Engineering in Ain Shams University (ASU)

Who gave me a lot of his time and effort, I am going to be always indebt for both of them, because without their encouragement and support I wouldn't have completed this study.

I cannot express enough of my appreciation to my mother who took care of my sons during my long study and always encouraged me to study hard. I owe her too much. ...At last but not least, I want to say thanks to my husband who encourages me to apply for this study opportunity and kept giving me support and love to help me finish my study successfully. My thanks also go to those whose names are not mentioned here but encouraged me and helped me during my research in one way or another. Thank you all.

# ABSTRACT

During the course of 20<sup>th</sup> century, air-transport has become one of the world's most influential industries. Aviation facilitates the expansion of world trade and provides opportunities for travel and tourism.

Aviation is one of the worldwide environmental problems. Airports face several environmental constraints including noise. Aircraft noise is the most significant environmental problem arising from arriving and departing of aircrafts. Therefore, airport related noise is an important issue that affects the passengers, the surrounding communities and nearby residential areas.

Hurghada airport is one of the key drivers of the economic growth of Egyptian airports. Over seven million passengers travelled through Hurghada airport every year. The expected increase in 2030 is twelve million. It is generally accepted that significant improvements to the environmental impacts of aircraft noise will be needed if the long-term growth of air transport is to be sustained.

The main goal of the study is the reduction of noise levels and its mitigations at Hurghada airport and surroundings area; to manage negative impacts of noise to make the right balance with positive economic and social benefits of the airports.

Reduction of noise levels around airports and nearby communities can be achieved through; Implementation of noise mitigation schemes, engaging communities to understand their concerns and Land-use planning and management to reduce the noise sensitive areas or to change activities to be compatible with airport. On the other hand, to preserve the quietest areas towards sustainable development.

| <b>Symbol</b>            | <b>Definition</b>   |
|--------------------------|---|
| <b>A-weighted</b>        | A standard and frequency weighting or filter used to reflect the frequency response of the average human ear                  |
| <b>Contour</b>           | A line of constant value of an aircraft noise index around an airport   |
| <b>dB</b>                | Unit of level- measurement on a logarithmic scale of ratio  |
| <b>Event</b>             | A discrete noise occurrence caused by the passage of an airplane  |
| <b>Exposure level</b>    | Exposure measured on a decibel scale  |
| <b>Flight path</b>       | The trajectory of an aircraft in flight in 3-dimensional space  |
| <b>Footprint</b>         | Contour of constant event level for one approach and/or departure operation of a single aircraft                              |
| <b>Hz</b>                | Hertz, a standard measure of frequency , cycles per second  |
| <b>ICAO</b>              | International civil aviation organization   |
| <b>ISO</b>               | International organization of standardization   |
| <b>LAF<sub>max</sub></b> | the highest level of environmental noise occurring during the measurement time  |
| <b>LAF<sub>min</sub></b> | Lowest level of environmental noise occurring during the measurement time   |
| <b>L<sub>day</sub></b>   | Average sound pressure level over 1 night. this night can be chosen so that it is representative of longer period 12-16 hours |

| <b>Symbol</b>    | <b>Definition</b>  |
|------------------|--|
| <b>L night</b>   | Average sound pressure level over 1 night. this night can be chosen so that it is representative of longer period 8 hours  |
| <b>DNL</b>       | Composed of the long-term A-weighted average sound level for day/evening/night respectively plus 0/5/10 dB   |
| <b>L den</b>     | Average sound pressure level over all days, evening and nights in a year. In the evening value gets a penalty of dB and the night value of 10dB                                  |
| <b>L A eq, T</b> | A-weighted-equivalent continuous noise level Calculates a constant level of noise with the same energy content as the varying acoustic noise signal being measured during time T |
| <b>SEL</b>       | Sound exposure level contains the same amount of acoustic energy over a normalized one second as the actual noise event under consideration                                      |
| <b>WHO</b>       | World health organization  |
| <b>ATC</b>       | Aircraft traffic control   |
| <b>FAA</b>       | Federal Aviation Administration  |
| <b>ACI</b>       | Airports council International   |
| <b>CDA</b>       | Continuous descent approach  |
| <b>NADP</b>      | Noise abatement departure procedure  |
| <b>CAEP</b>      | Committee on aviation environmental protection   |

# CONTENTS

Abstract

Acknowledgement

Aim of Work

## CHAPTER ONE

### INTRODUCTION

#### 1 Introduction

|  |    |
|--|----|
| 1.1 Noise pollution as a worldwide problem     | 1  |
| 1.2 Sources of noise                           | 2  |
| 1.3 Environmental noise                        | 2  |
| 1.3.1 Common types of environmental noise      | 3  |
| 1.3.2 Threshold of audibility                  | 4  |
| 1.4 Air traffic noise                          | 5  |
| 1.5 Aviation and its impact on the Environment | 6  |
| 1.5.1 Adverse Effects of Noise on Human Health | 8  |
| 1.5.2 Auditory Effects of noise on Humans      | 9  |
| 1.5.3 Non-Auditory effects of noise on humans  | 10 |



|  |    |
|--|----|
| 1.5.4 Psychological effects of noise on humans | 10 |
| 1.6 Airport Environment                        | 12 |
| 1.7 Airport Noise                              | 13 |
| 1.8 Environmental noise propagation            | 14 |
| 1.8.1 Propagation of Sound                     | 14 |
| 1.8.2 Temperature                              | 15 |
| 1.8.3 Wind                                     | 16 |
| 1.8.4 Factors influence aircraft noise         | 16 |
| 1.8.5 Air Traffic Noise Management             | 17 |
| 1.9 Area of Study                              | 18 |
| 1.10 The Objective of the Study                | 20 |
| 1.11 Basic Concepts                            | 20 |
| 1.11.1 NOISE                                   | 20 |
| 1.11.2 Noise Scales                            | 21 |
| 1.11.3 Frequency Weighting                     | 22 |
| 1.11.4 Noise Metrics                           | 22 |
| 1.12 Measuring Single Event Noise.....         | 24 |

## **CHAPTER TWO**

### **LITERATURE REVIEW**

|  |           |
|--|-----------|
| <b>2. Literature Review</b>                        | <b>26</b> |
| 2.1 Literature Review of Previous Studies          | 26        |
| 2.2 noise models                                   | 33        |
| 2.2.1 The simulation approach                      | 34        |
| 2.2.2 The integrated approach                      | 35        |
| 2.3 Calculating noise levels                       | 35        |
| 2.4 Legislations Framework                         | 40        |
| 2.4.1 International Agreements                     | 40        |
| 2.4.2 Efforts by the ICAO Environmental Protection | 41        |
| 2.4.3 Laws and Legislations issued by the states   | 42        |
| 2.4.4 FAA guidelines and regulations               | 44        |

## **CHAPTER THREE**

### **MATERIAL AND METHOD**

|                               |           |
|-------------------------------|-----------|
| <b>3. Material and Method</b> | <b>46</b> |
| 3.1 Aim of Study              | 46        |

|  |    |
|--|----|
| 3.2 Methodology of Study                         | 46 |
| 3.3 Equipment & Instrumentation                  | 47 |
| 3.3.1 Sound level meter                          | 47 |
| 3.3.2 Sound Level Meter Calibrator Type 42313    | 48 |
| 3.3.3 Environmental Noise Measurements Reference | 49 |
| 3.3.4 Selection of Environmental Noise           | 49 |
| Measurements Locations                           | 49 |
| 3.3.5 Measurement Technique and precautions      | 50 |
| 3.4 Measurement Locations                        | 52 |
| 3.5 Aircraft Identification                      | 54 |
| 3.6 INM Basic Principle                          | 55 |
| 3.7 Noise Metric of INM                          | 57 |
| 3.8 INM Overview & Description                   | 58 |
| 3.8.1 (INM) Data input                           | 58 |
| 3.8.2 (INM) Output                               | 59 |
| 3.8.3 Grid Points                                | 59 |
| 3.8.4 Noise Contours                             | 60 |
| 3.8.5 Noise Modeling                             | 61 |

|                                     |    |
|-------------------------------------|----|
| 3.8.6 Methodology of the Prediction | 62 |
|-------------------------------------|----|

## **CHAPTER FOUR**

### **RESULTS AND DISCUSSION**

|   |           |
|---|-----------|
| <b>4. Results and Discussion</b>                                      | <b>63</b> |
| 4.1 Results of Measurements Outside Hurghada Airport                  | 63        |
| 4.2 Measurement Locations Inside Hurghada Airport                     | 66        |
| 4.3 Identification of Aircraft Types                                  | 66        |
| 4.4 Analysis of Noise Measurements Outside<br>Hurghada Airport        | 67        |
| 4.5 Analysis of Noise Measurements Inside<br>Hurghada Airport         | 70        |
| 4.5.1 Some Aircraft Profile for Some Locations                        | 72        |
| 4.6 Determination of the Highest Noise Level in All Locations         | 75        |
| 4.7 Measurements Results  | 77        |
| 4.7.1 Discussion of Measurements Results                              | 77        |
| 4.7.2 Compliance of Measured Results with Environmental<br>Law 9/2009 | 80        |
| 4.8 Methodology of Prediction   | 85        |
| 4.8.1 Airport Information   | 85        |

|  |     |
|--|-----|
| 4.8.2 Flight Tracks  | 86  |
| 4.8.3 Flight Operation   | 86  |
| 4.8.4 The Assumption of INM model  | 88  |
| 4.8.5 Air-Traffic data   | 88  |
| 4.8.6 Model prediction   | 89  |
| 4.8.7 Identification of Noise Impacted Area  | 95  |
| 4.8.8 Discussing the produced Noise prediction maps                                    | 96  |
| 4.8.9 Discussing the possible scenarios of new-Runway                                  | 98  |
| 4.9 Model prediction   | 99  |
| 4.9.1 Aircraft noise model validation  | 104 |
| 4.9.2 Checking Forecast  | 105 |
| 4.9.3 Discussing the comparison between measured<br>results and INM Predicted results. | 109 |

## **CHAPTER FIVE**

### **NOISE REDUCTION AND MANAGEMENT**

|  |            |
|--|------------|
| <b>5. Noise Reduction and Management</b> | <b>110</b> |
| 5.1 Balanced approach                    | 110        |

|  |     |
|--|-----|
| 5.1.1 Reduction at the source                            | 112 |
| 5.1.2 Mitigation and Land-use planning                   | 113 |
| 5.2 Land-use planning and Management of Hurghada airport | 115 |
| 5.3 Establishment of noise zones for Hurghada airport    | 120 |
| 5.4 Noise Abatement Operational Procedures               | 122 |
| 5.4.1 Noise abatement Flight procedure                   | 124 |
| 5.4.2 Managing Noise from Arriving Aircraft              | 124 |
| 5.4.3 Steeper Approaches                                 | 126 |
| 5.4.4 Low Power Low Drag                                 | 127 |
| 5.4.5 Managed approach speeds                            | 128 |
| 5.4.6 Reduced Landing Flap                               | 128 |
| 5.4.7 Delayed deployment of landing gear                 | 129 |
| 5.4.8 Continuous climb operation                         | 129 |
| 5.5 Spatial Management                                   | 131 |
| 5.6 Ground management                                    | 131 |

## CHAPTER SIX

### CONCLUSIONS AND RECOMMENDATION

|   |            |
|---|------------|
| <b>6. Conclusion</b>  | <b>134</b> |
| 6.1 Legislative framework                                     | 136        |
| 6.2 Noise Abatement Plan                                      | 136        |
| 6.3 The Recommended Noise Abatement Measures in<br>Three Axes | 138        |
| 6.4 Land Use planning to reduce noise level around airport    | 138        |
| 6.5 Noise Reduction at airport                                | 139        |
| 6.6 Recommendations   | 139        |
| 6.7 The principles of Action Plan                             | 140        |
| 6.8 General Recommendation                                    | 142        |
| References  | 144        |
| Summary   |            |
| Arabic Summary  |            |