Air pollution modeling of the industrial complexes and cities in the Kurdistan region using AERMOD view

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Abstract

Today, pollutant gases from vehicular traffic and industrial activities affect many people and have brought a lot of health problems. Having knowledge about how many people are exposed by which gas is very essential. So, the importance of air pollution prevention has been increasing in recent years, due to increasing knowledge of pollution sources and their pollution levels. The AERMOD view software estimates of concentrations depend on the availability and quality of meteorological observations, as well as the specifications of surface characteristics at the observing site. This model is able to simulate dispersion of gases emitted from all kinds of sources, such as point, line, and surface. In urban areas, we focus more on the point sources (i.e. industries) and line sources (i.e. streets).

1 Introduction

Today, Iraqi Kurdistan is one of the fast growing regions. Usually, fast industrial and urban development brings more environmental impacts and has a strong pressure on the natural and human environment. Among the environmental impacts of industrial and urban development, air pollution is the most important. So, it is vital to know how the air pollutants disperse through the environment. Moreover, it is important to know which pollutant gases affect the natural

environment and human population. By knowing this, the managers and policy makers will have the better plan to manage the cities or industries in sustainable way.

The importance of air pollution prevention has been increasing in recent years, due to increasing knowledge of pollution sources and their pollution levels. National air quality standards have been established by the United States Clean Air Act to protect man and the environment from damage by air pollutants [5]. Chronic exposure to air pollutants is a worldwide problem. The World Health Organization (WHO) announced that every year approximately 2.7 million deaths can be attributed through air pollution [5].

“Acid Rain,” or more precisely acid precipitation, is the word used to describe rainfall that has a pH level of less than 5.6. This form of air pollution is currently a subject of great controversy because of its worldwide environmental damages. For the last ten years, this phenomenon has brought destruction to thousands of lakes and streams in the United States, Canada, and parts of Europe. Acid rain is formed when oxides of nitrogen and sulfite combine with moisture in the atmosphere to make nitric and sulfuric acids. These acids can be carried away far from its origin. The two primary sources of acid rain are sulfur dioxide (SO_2), and oxides of nitrogen (NO_x). Acid rain does not only affect organisms on land, but also affects organisms in aquatic biomes.

Dispersion is the process of air pollutants emitted from sources such as industrial plants and vehicular traffic dispersing in the ambient atmosphere [6]. An air quality dispersion model is a series of equations that mathematically describe the behavior of pollutants in the air. It provides a cause-effect link between the emissions into the air and the resulting air pollution concentrations. Dispersion models have been used in many different applications, but have traditionally been used for air quality assessments in support of decisions regarding approvals and permits for regulated sources. Dispersion models use a set of scientific equations to describe and simulate the dispersion, transformation and deposition of pollutants emitted into the atmosphere. In addition to the quantity and type of pollutants released into the air, factors such as topography, atmospheric conditions, and the pollutant source location also have a significant effect on air quality. A dispersion model is essentially a computational procedure for predicting concentrations downwind of a pollutant source, based on knowledge of the emissions characteristics (stack exit velocity, plume temperature, stack diameter, etc.), terrain (surface roughness, local topography, nearby buildings) and state of the atmosphere (wind speed, stability, mixing height, etc.). The model has to be able to predict rates of diffusion based on measurable meteorological variables such as wind speed, atmospheric turbulence, and thermodynamic effects. The algorithms at the core of air pollution models are based upon mathematical equations describing these various phenomena which, when combined with empirical (field) data, can be used to predict concentration distributions downwind of a source [3].

Currently used dispersion models, such as the AMS/EPA Regulatory Model (AERMOD), process routinely available meteorological observations to construct model inputs. Thus, model estimates of concentrations depend on the

availability and quality of meteorological observations, as well as the specification of surface characteristics at the observing site [1]. AERMOD requires steady and horizontally homogeneous hourly surface and upper air meteorological observations [1].

2 Study objectives

We aim to:

- 1) model the dispersion of pollutant gases from both major industrial complexes such as oil industries (oil refineries), power plants as well as vehicular traffic in the cities;
- 2) compare the outputs with Air Quality Standards to estimate the share of these sources in ambient air pollution;
- 3) make a comparison with nearby monitoring data to indicate reasonability of predicted concentrations and usefulness of AERMOD as a tool for approaching the potential cumulative impacts of air pollution from multiple sources;
- 4) overlay the outputs with a landuse map of the study area to realize which populations are affected and which concentrations they are exposed by;
- 5) overlay the outputs with an ecosystems map of the study area to realize which ecosystems are affected and which concentrations they are exposed by. The effects of predicted threshold violations on fragile ecosystems will be discussed.

3 Material and methods

The Lakes Environmental's AERMOD ViewTM version 7.6.1 software will be used to model the dispersion on the gases. The AERMOD atmospheric dispersion modeling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 kilometers) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data preprocessor (AERMET) that accepts surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- A terrain preprocessor (AERMAP) whose main purpose is to provide a physical relationship between terrain features and the behavior of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

The dispersion of pollutants released to the atmosphere is highly dependent on the meteorological conditions into which it is released. Meteorology was supplied by Lakes Environmental in SAMSON format for study area stations

prior to processing with AERMET. AERMOD is a Gaussian plume model that uses a skewed bi-Gaussian probability density function under convective conditions when vertical plume dispersion is non-Gaussian [6].

This process includes the following steps:

- 1- At first, AERSCREEN applied as AERMOD screen model.
- 2- After ensuring its propriety, five main pathways will be defined in model and project scenarios will be considered.
- 3- Required data must be provided:
 - Two kinds of meteorology data are required: surface meteorology data such as temperature, speed, direction of wind; upper air meteorology data such as Heat flux, Monin-Obukov length, Albedo rate and etc. Importing data in this step is the most difficult data importing.
 - Source related data such as height of stacks and flares, emission rate.
 - Terrain related data includes DEM (Digital Elevation Model), location of sources and receptors.
- 4- The model will run and concentration iso-contours with relative exact location are the output of it.
- 5- Expected concentrations will compare with nearby and measured concentrations ensuring the accuracy of predictions.
- 6- Expected concentrations will compare with limits, thresholds and standards to determine effects of pollutants on human health, important and economic animal and plant species and some other targets.

4 Outputs

- 1) Dispersion map of each pollutant gases from point sources such as industries.
- 2) Dispersion map of each pollutant gases from line sources such as streets.
- 3) By overlaying the layer of different pollutant gases we will get the map of the cumulative and even synergistic effects.
- 4) By overlaying the dispersion maps with landuse map, we will find the affected different land uses specially the natural ecosystems.
- 5) By overlaying the dispersion maps with population map, we will found how many people are affected by a specific pollutant gas.

Output of the model can be exported in Google Earth and the location of concentrations with maximum and minimum amount can be observed. So, according to this ability of the model, appropriate management measures will be considered to mitigate the effects of concentrations higher than the limits.

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