Course Learning Outcomes for Unit II

Upon completion of this unit, students should be able to:

1. Discuss how particle size is measured and describe how the characteristics of particles affect their motion through the atmosphere.
2. Define aerosol and aerodynamic diameter and discuss how the aerodynamic diameter is used to describe how particles settle out of the atmosphere and into the respiratory tract.
3. Identify the photochemical reactions that lead to the formation of ozone in the troposphere.
4. Define and describe primary and secondary air pollutants.
5. Identify the four categories of air samples and describe the application of each.
6. Describe particle sampling and analysis devices and techniques.
7. Describe gas sampling and analysis devices and techniques.
8. Identify and discuss the elements of quality assurance/quality control that are important in developing an analytical protocol.

Reading Assignment

Chapter 3: Important Properties of Air Pollutants

Chapter 4: Sampling and Analysis for Health Assessments

Click here to access as PDF of “Characterizing the Range of Children’s Pollutant Exposure during School Bus Commutes.”


Unit Lesson

In Unit I, we discussed some of the main sources of air pollution and how the pollutants are transported through the troposphere. In Unit II, we will explore these topics in greater detail. Understanding how particles and gases behave in the atmosphere requires knowledge of the physical and chemical characteristics of particles and gases. We begin with a discussion of aerosols. An aerosol is “a disperse system in air” or a “relatively time-stable suspension of small liquid and/or solid particles in a gas” (Phalen & Phalen, 2013, p. 43). Aerosols range in size from 0.001 to 100 microns (Phalen & Phalen, 2013). Because the shape of an individual particle in an aerosol is often irregular, its diameter is described in terms of the behavior of a spherical particle under specific laboratory conditions. This diameter is called the aerodynamic diameter. The aerodynamic diameter can be used to predict a particle’s behavior in air. These predictions can be useful in determining not only how a pollutant will be transported through the atmosphere, but also how it will be deposited into the respiratory tract.

As you read the second section of Chapter 3 (II. Particle Basics), keep in mind how these various characteristics would influence the transport and health effects of air pollutants. For example, particles suspended in air are bombarded by other suspended particles, creating random movement. This random movement is called Brownian motion. It is helpful to view an animation of this type of motion. Type “Brownian Motion HD” in the search box of a video search website. After viewing the animation, think about how that
type of motion would diffuse mercury particles from a smokestack or radon particles from a basement to the living space of a home.

The dynamic characteristics of a particle are only one of many characteristics that determine how it will be transported and deposited in the atmosphere and in the body. For example, particle shape, surface area, and electrical charge play a significant role in the behavior of atmospheric particles. There are four basic types of shapes: (1) globular, (2) plate-like, (3) fibers, and (4) irregular. Each of these shapes will have a different surface area, which determines its interaction with surrounding gases in the air as well as where the particles deposit in the body after they are inhaled. The electrical charge of a particle determines how quickly it will coagulate with other particles and how quickly it will deposit on surfaces (Phalen & Phalen, 2013).

As these particles move through the atmosphere, they react with other particles as well as with solar electromagnetic energy. When gases absorb this energy, photochemical reactions that might not have otherwise occurred become possible (Phalen & Phalen, 2013). It is the photoactivation of nitrogen dioxide that provides the single oxygen molecule that reacts with O2 to form ozone (O3) in the troposphere. Since the Industrial Revolution, the amount of ozone in the troposphere has increased by 100%-200% in some locations, according to Fishman et.al (n.d.). Breathing ozone can cause “chest pain, throat irritation, and congestion. Ground-level ozone also can reduce lung function and inflame the linings of the lungs” (U.S. Environmental Protection Agency, 2011).

Problems such as tropospheric ozone require us to be able to make quantitative and qualitative measurements of pollutants in the atmosphere. Levels of pollution in the air can vary depending on the time of day, weather conditions, and location. How can a representative sample be obtained? There are several factors that should be taken into account when collecting air samples. Phalen & Phalen (2013) list four main categories of air samples: (1) source emission, (2) area sample, (3) population exposure sample, and (4) a personal sample. A source emission is a direct measurement of a source such as a smokestack. An area sample targets a specific area, such as a neighborhood downwind from a power plant. If you are trying to analyze the exposure of a particular group, such as workers on a factory floor, you would take a population exposure sample. Lastly, the purpose of a personal sample is to measure the exposure of one individual. Knowing the purpose of the air sampling is important to the proper selection of the number, methods, and location of samples to be taken.

In the spring of 2002, the California Air Resources Board (CARB) conducted a study to measure children’s exposure to vehicle-related pollutants during their bus commutes to and from school. The researchers sampled not only the bus exhaust, but air from inside the bus at different seating areas as well as outside the bus. Additionally, measurements of the air quality inside the bus were taken with the windows open and closed to simulate real-world conditions. This type of sampling would be categorized as a population exposure sample. A summary of the study can be found in your required reading under “Characterizing the Range of Children’s Pollutant Exposure During School Bus Commutes.” As you read through the summary, take note of the sampling procedures that were put in place by the researchers in an attempt to get a truly representative sample of the air that the children were exposed to during their bus rides.

Not only did the researchers in the CARB study have to determine how to get a representative sample, they also had to decide on what instruments to use for the pollutants they wanted to measure. If you choose to access the full report of this study, you will find on page 20 a list of the instruments used to sample each pollutant. You will see various instruments from Chapter 4, section IV (Particle Sampling) of the textbook on this list. Your textbook provides a thorough description of many of these instruments. For example, a Harvard Impactor was used in the study to measure PM2.5 concentrations. The Impactor uses inertial collection “to remove larger particles from the air stream by impaction on a filter” (Phalen & Phalen, 2013, p. 92). You can see the Harvard Impactor and how it is used in the field by searching for “Harvard Impactor Animation” in your favorite search engine. The researchers also used gas chromatographs (115), aethalometers (99), and high-performance liquid chromatography (HPLC) (p. 115). Reading through the general descriptions is important, but it will be a more interesting exercise to pair up these descriptions with the instruments on the CARB study list so that you can see how researchers are using them in practice. On page 24 of the CARB study, you can view two photographs of the instrumentation on the bus. Notice how complicated it can be to get a representative sample!

Chapters 3 and 4 discuss the motion of air pollutant particles on a small scale, as well as how we sample and analyze these particles to determine their impact on human health. Although it is complicated to devise a high-quality sampling plan, “questionable methods lead to questionable results” (Phalen & Phalen, 2013, p. 92).
82). Therefore, it is important to have an understanding of the factors that go into the data collection for the
cience that subsequently drives our air quality policy decisions.

References

science for all seasons all the time. The Global Program. Retrieved from

Burlington, MA: Jones & Bartlett Learning.

http://www.epa.gov/air/ozonepollution/

Key Terms

1. Active sampling
2. Aerodynamic diameter
3. Aerosol
4. Area sample
5. Brownian motion
6. Method detection limit
7. Partial pressure
8. Passive sampling
9. Personal sample
10. Photochemistry
11. Population exposure sample
12. Primary pollutant
13. Secondary pollutant
14. Source emission