Instructor Notes

Assessing Risks for Inhalation and Ingestion of Pollutants

This investigation focuses on the basics of human and ecological risk assessment. The activity uses hypothetical scenarios to investigate inhalation of an airborne pollutant and ingestion of a waterborne pollutant. Working in pairs, participants investigate differences in overall exposure to contaminants by calculating inhalation intakes and water ingestion doses that result from varying body weight, years of exposure, inhalation or water ingestion rates, and duration of each exposure event for different hypothetical individuals. By working through these calculations, participants gain an understanding of risk assessment and of what conditions are most vital in reducing exposures to air- and waterborne pollutants. They also gain an awareness of how difficult it is to find clear-cut answers to environmental problems.

The activity is written for workshop participants and may need modification for classroom use.

Suggested Background Readings

- An Introduction to Toxicology
- A Scientific View of Risk

National Science Education Standards for Grades 5–12

Science as Inquiry

- Abilities Necessary to Do Scientific Inquiry

  Use technology and mathematics to improve investigations and communications. Students use a calculator to determine inhalation intake or water ingestion dose of hypothetical contaminants to demonstrate that factors like concentration level, total years of exposure, number of exposure events, exposure duration, and body weight affect human risk assessment.

  Formulate and revise scientific explanations using logic and evidence. Students participate in a discussion on methods and approaches to risk assessment. Then, after calculating inhalation intake or water ingestion dose of hypothetical toxins, students use logic and evidence to validate or disprove their initial thoughts on risk assessment.

Science in Personal and Social Perspectives

- Risks and Benefits

  Individuals can use a systematic approach to thinking critically about risks and benefits. Students learn that quantification of toxin exposure rates can serve as a measurement tool for assessing human risk.

Materials

Per pair of participants

- calculator
- set of 4 cards (one Inhalation Rate card, one Water Ingestion Rate card, one Total Years of Exposure card, and one Body Weight card)

Per class

- 4 containers such as bags or buckets

Getting Ready

Using the masters provided, make photocopies of the Exposure Cards using a different color for each category. Make enough cards for each pair of participants to have one card of each color. Cut apart and fold all the cards, putting each color of card in a separate container such as a bag or bucket. At the start of the investigation, participant pairs draw one card from each category.

To help compile class data, use the following tables to create overheads or tables on a blackboard.

Class Data Chart for Calculating Inhalation Intake (*I*)

C Concentration of Inhalant (mg/kg)	***Ir*** Inhalation Rate (kg/hour)	***Yr*** Total Years of Exposure (years)	***E*** Exposure Events (events/year) If *Yr* = 65, *E* = 365 If *Yr* = 30/10/1, *E* = 250	***T*** Duration of Exposure (hours/event) If *Yr* - 65, *T* = 24 If *Yr* = 30/10/1, *T* = 8	***Bw*** Body Weight (kg)	***D*** Days over Which Exposure Is Averaged	***I*** Inhalation Intake of Contaminant (mg/kg/day)
0.001							
0.001							
0.001							
0.001							
0.001							
0.001							
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0.001							

Class Data Chart for Calculating Water Ingestion Dose (*IDw*)

C Concentration of Contaminant (mg/L)	***Irw*** Water Ingestion Rate (L/day)	***Yr*** Total Years of Exposure (years)	***E*** Exposure Events (days/year) If $Yr = 65$, then $E = 365$ If $Yr = 30/10/1$, $E = 250$	***Bw*** Body Weight (kg)	***D*** Days over Which Exposure Is Averaged	***IDw*** Water Ingestion Dose (mg/kg/day)
0.01						
0.01						
0.01						
0.01						
0.01						
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Procedure Notes and Outcomes

An initial discussion should include the steps involved in a risk assessment and several of the methods and approaches currently used in this field. (See "A Scientific View of Risk" Background.) After the initial discussion, divide the class into pairs. Each pair needs a calculator and four cards (one of each color). Instruct participants to use the data on their cards to calculate inhalation intake and water ingestion dose of the contaminants. Before doing the activity, have the class discuss what factors they think will be significant in their calculations. As they complete their calculations, ask group members to add their data to the class data charts.

Participants should recognize that many factors are included in a human risk assessment. (See "An Introduction to Toxicology" Background.) From their calculations, have class members discuss whether their initial thoughts were validated or disproved. Also remember to include a discussion of the concentration levels for both the inhalant and water contaminant calculations. Specifically, how would the results change if the concentration levels were increased or decreased rather than remain constant? Have participants try several different concentration levels in their calculations and compare these results to the initial class data.

As time permits, discuss other factors that could be included in future studies. You may also want to connect this investigation to other topics such as dermal exposure, human health, and environmental science.

End the investigation with a final consideration of the data and discussion questions.

Plausible Answers to Questions

1. Look for trends in the data.
   Lifetime exposure is more severe than exposure at work, since the former takes place 365, rather than 250, days per year and 24, rather than 8, hours per day.
2. What conclusions can be made from your data in terms of total years of exposure, body weight, and air inhalation (or water ingestion) rate?
   Body weight is a significant factor when total years of exposure and inhalation/ingestion rates are equal for different people. The lower the body weight, the higher the exposure will be.
3. What happens if the concentration levels are changed? Show your calculations to support your answer.
   Increasing the concentration level increases a person's exposure.
4. Several arbitrary values were used in setting up this exercise. For example, the concentration of the toxin never changed and each person maintained their starting body weight at a constant level, in some cases for over a period of 65 years. Now that

you have considered the effects of such factors as they were presented in the exercise, think about them again more realistically. What would you want to know in order to improve your assessment of exposure?

One would need to know how toxin levels are measured. For air samples, measurement may involve using monitoring equipment operating in different parts of the environment where the individuals are exposed. In some cases, individual samplers worn on the shirt may be used for sample collection.

Information on water purification and chemical analysis in water treatment plants and workplace drinking water samples would also be necessary. Multiple samples collected over time would allow scientists to determine the highest and average doses.

Lifestyle information may also be beneficial. Suppose the same toxin is also taken up from smoking or chewing tobacco, through food via the food chain, or through the skin while swimming.

Exposure Cards

Inhalation Rate (*Ir*) Heavy Work 4.3 kg/hour	**Inhalation Rate (*Ir*)** Moderate Work 2.5 kg/hour	**Inhalation Rate (*Ir*)** Light Work 0.8 kg/hour	**Inhalation Rate (*Ir*)** Resting 0.7 kg/hour
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Water Ingestion Rate (*Irw*) 3.0 L/day	**Water Ingestion Rate (*Irw*)** 2.0 L/day	**Water Ingestion Rate (*Irw*)** 1.0 L/day	**Water Ingestion Rate (*Irw*)** 0.5 L/day
Water Ingestion Rate (*Irw*) 3.0 L/day	**Water Ingestion Rate (*Irw*)** 2.0 L/day	**Water Ingestion Rate (*Irw*)** 1.0 L/day	**Water Ingestion Rate (*Irw*)** 0.5 L/day
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Water Ingestion Rate (*Irw*) 3.0 L/day	**Water Ingestion Rate (*Irw*)** 2.0 L/day	**Water Ingestion Rate (*Irw*)** 1.0 L/day	**Water Ingestion Rate (*Irw*)** 0.5 L/day

Total Years of Exposure (*Yr*) Lifetime 65 Years	**Total Years of Exposure (*Yr*)** Career Job 30 Years	**Total Years of Exposure (*Yr*)** Short-Term Job 10 Years	**Total Years of Exposure (*Yr*)** Temporary Job 1 Year
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Total Years of Exposure (*Yr*) Lifetime 65 Years	**Total Years of Exposure (*Yr*)** Career Job 30 Years	**Total Years of Exposure (*Yr*)** Short-Term Job 10 Years	**Total Years of Exposure (*Yr*)** Temporary Job 1 Year

Body Weight (*Bw*) 82 kg	**Body Weight (*Bw*)** 70 kg	**Body Weight (*Bw*)** 62 kg	**Body Weight (*Bw*)** 36 kg
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References

Haroun, L.A.; MacDonell, M.M.; Peterson, J.M.; Fingleton, D.J. "Risk Assessment at a Superfund Site: A Case Study," *The Environmental Professional.* 1992, *14,* 238–247.

Krimsky, S.; Golding, D. "Factoring Risk into Environmental Decision Making"; *Environmental Decision Making: A Multidisciplinary Perspective;* Chechile, R.A., Carlisle S., Eds.; Van Nostrand Reinhold: New York, 1992.

Activity Instructions

Assessing Risks for Inhalation and Ingestion of Pollutants

What factors are most significant when assessing human exposure to air pollutants and water contaminants? You will discover how several factors affect overall exposure to a toxin in the air we breathe and in the water we drink.

Procedure

With a partner, obtain a calculator and a complete set of four cards (one of each color). Use the data on these cards and the information from the sections below to calculate inhalation intake and water ingestion dose of the contaminants. Use the Total Years of Exposure and Body Weight cards for both calculations. Add your group's data to the class data charts.

Formula for Estimating Inhalation Exposures

The inhalation intake is measured in milligrams of pollutant per kilogram of body weight of the exposed individual per day. This calculation assigns a numerical value to an individual that can then be used for comparison among different individuals. In this exercise, the milligrams of pollutant, or concentration, will be kept constant at 0.001 mg/kg (0.001 mg of pollutant per 1 kg of air). Holding the concentration constant will illustrate the differences in inhalation intake when only the other factors are varied.

$$I = \frac{C \times Ir \times T \times E \times Yr}{Bw \times D}$$

Where:

I = Inhalation intake of contaminant (mg of pollutant/kg of body weight/day)

C = Concentration of inhalant (mg of pollutant/kg of air)

Ir = Inhalation rate (kg of air/hour)

T = Duration of each exposure event (hours/event)

E = Number of exposure events per year (events/year)

Yr = Total years of exposure (years)

Bw = Body weight over exposure period (kg of body weight)

D = Days over which exposure is averaged (days calculated by multiplying E x Yr)

For calculations:

E = 250 days/year for a career exposure; 365 days/year for a lifetime exposure

C = 0.001 mg of pollutant/kg of body weight

T = 8 hours for a job; 24 hours for a lifetime

Formula for Estimating Water Ingestion Exposures

The water ingestion dose is measured in milligrams of pollutant per kilogram of body weight of the exposed individual per day. This calculation assigns a numerical value to an individual that can then be used for comparison among different individuals. In this exercise, the milligrams of pollutant, or concentration, will be kept constant at 0.01 mg/L (0.01 mg of pollutant per 1 L of water). Holding the concentration constant will illustrate the differences in water ingestion dose when only the water ingestion rate, body weight, and years of exposure are varied.

$$IDw = \frac{C \times Irw \times E \times Yr}{Bw \times D}$$

Where:

IDw = Water ingestion dose (mg of pollutant/kg of body weight/day)

C = Concentration of contaminant (mg of pollutant/liter of water)

Irw = Water ingestion rate (L/day)

E = Number of exposure events per year (days/year)

Yr = Total years of exposure (years)

Bw = Body weight over exposure period (kg of body weight)

D = Days over which exposure is averaged (days calculated by multiplying *E* x *Yr)*

For calculations:

C = 0.01 mg of pollutant/liter of water

E = 250 days/year for a career exposure; 365 days/year for a lifetime exposure

Questions

1. Look for trends in the data.
2. What conclusions can be made from your data in terms of total years of exposure, body weight, and air inhalation (or water ingestion) rate?
3. What happens if the concentration levels are changed? Show your calculations to support your answer.

4. Several arbitrary values were used in setting up this exercise. For example, the concentration of the toxin never changed and each person maintained their starting body weight at a constant level, in some cases for over a period of 65 years. Now that you have considered the effects of such factors as they were presented in the exercise, think about them again more realistically. What would you want to know in order to improve your assessment of exposure?