

Pesticides in My Smoothie Bowl?

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Abstract

Teaching resources, especially active learning pedagogy, are scarce for toxicology compared to what is available for other disciplines. Ecological and human health risk assessment are important aspects of toxicology and are routinely used by government agencies to regulate the registration and usage of many chemicals. Most traditional toxicology classes do not cover how such risk assessments are carried out in real-world scenarios. We developed this case study to introduce concepts and processes of ecological and human health risk assessment in pesticide registration by the U.S. EPA. In Part 1, dialogues among three college friends introduce organic food, pesticides, and the concept of risk. Part 2 and Part 3 build on Part 1 and focus on ecological risk assessment and human health risk assessment, respectively. At the end of each section, students select appropriate exposure and toxicity endpoints to perform a mini-risk assessment and draw conclusions regarding risk. In Part 4, students examine real pesticide monitoring data in various foods and perform basic data organization and analysis. This case is appropriate for upper-level college students taking toxicology or other environmental science related courses. With modifications, the case study may also be suitable for introductory level environmental and biological science students.

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Supporting Materials: Supporting Files S1. Pesticides in my Smoothie Bowl – Part 1. Pre-class assignment; S2. Pesticides in my Smoothie Bowl – Part 2. Ecological risk assessment; S3. Pesticides in my Smoothie Bowl – Part 3. Human risk assessment; S4. Pesticides in my Smoothie Bowl – Part 4. A peek into pesticide monitoring data; and S5. Pesticides in my Smoothie Bowl – Answer key

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Learning Goals

Toxicology Learning Framework

- How are organisms living in the natural environment affected by natural and anthropogenic toxicants?
- How is the science of toxicology applied to government regulations to ensure the protection of individuals and the environment?
- How does the concept of dose-response relate to toxicology?

Science Process Skills

- Interpreting results/data
- Displaying/modeling results/data

Learning Objectives

Students will be able to:

- Define risk and differentiate hazard and risk
- Define risk assessment terminology including risk, toxicity, exposure, acute, chronic, LC50, EC50, NOEL/NOAEL, uncertainty factor (UF), safety factor (SF), and population adjusted dose (PAD).
- Describe applications of LC50, EC50, NOEL/NOAEL, uncertainty factor (UF), safety factor (SF), and population adjusted dose (PAD) in ecological and human risk assessment for regulatory purposes.
- Properly interpret toxicity and exposure data and select appropriate (i.e., normally the most protective) toxicity and exposure endpoints for screening level risk assessment for pesticides and potentially apply the same principles to other chemicals.
- Compare calculated ecological risk of pesticide exposure to levels of concern (LOC) and determine whether the risk is acceptable.
- Explain the extensive risk assessment process used by regulatory agencies to inform decisions of regulatory agencies.
- Organize and analyze large datasets of chemical monitoring data in Microsoft Excel or Google Sheets, including following manual instructions to read the data, locating a subset of data of interest, calculating basic statistics (i.e., mean, standard deviation, and standard error), and present the data in a graph.

INTRODUCTION

Even though educational resources for most subjects in biological and environmental sciences are readily available, teaching activities and materials for some highly specialized disciplines including toxicology are sparse. The only journal for publishing toxicology specific teaching pedagogy is the *Journal of Toxicological Education*, with only nine articles published since its establishment in 2013. A search conducted on July 20, 2021 using key words “toxicology” or “risk assessment” in the National Center for Case Study Teaching in Science (NCCSTS) database returned 16 relevant articles, a miniscule number compared to the hundreds of articles in other disciplines of biology and environmental science.

Despite being an integral part of toxicology, risk assessment is often considered an advanced topic that may not be taught until students reach graduate school. Some undergraduate environmental science and toxicology courses may introduce risk assessment, but it is often taught in traditional lecture format without real-world examples and applications or with active learning activities. Definitions on key terms and description of major steps are given but there is limited opportunity for students to apply and practice what they learn. As such, students may find it difficult to truly grasp the meaning of risk assessment terms and how the process is done. One case study published in NCCSTS aims to teach students concepts in human risk assessment (1), in which students calculate the cancer and non-cancer risks of tetrachloroethylene in drinking water and perform an abbreviated human health risk assessment. The case presents a realistic situation where residents of a community near a contaminant source may be exposed to the chemical via drinking water and offers scaffolded instructions for students to calculate risk and reach a conclusion.

Here, we developed a similar but more extensive teaching activity to teach students both ecological and human health risk assessment, and specifically, the key principles and steps adopted by the U.S. Environmental Protection Agency (EPA) during pesticide registration to inform regulatory decisions. We selected pesticides as the contaminants of interest because pesticides are widely used and ubiquitous in the environment. Additionally, risk assessment for pesticides is well developed and documented by regulatory agencies and this provides the perfect teaching material for students to learn this topic. In the U.S., the EPA is the government agency responsible for conducting risk assessment as part of the pesticide registration process to ensure pesticide products on the market do not cause unreasonable risk to humans and the environment. All risk assessment documents are readily available through the public docket as part of the registration process.

This lesson focuses on pesticide risk assessment in the U.S. and centers around a case study which employs dialogues between fictional characters (college friends) throughout the case to engage students and to introduce students to the main topics of the lesson. These characters discuss the potential presence of pesticides in fruit, the definition of risk, government practice of evaluating pesticide risk, as well as finding reference pesticide residue levels in food. We feel the discussions between the fictional college students may resonate among students who have similar concerns with

pesticide safety. For instance, Part 1 (Supporting File Pesticides in my Smoothie Bowl – Part 1. Pre-class assignment) begins with a conversation between the characters about the potential presence of pesticides in fruits and prompts students to think about what “organic” means. The conversation then transitions to a discussion on the concept of risk and how risk is determined which is tied to Part 2 (Supporting File S2. Pesticides in my Smoothie Bowl – Part 2. Ecological risk assessment).

After students gain some background knowledge on pesticides and terminology associated with risk in Part 1, they will follow instructions in Part 2 (ecological risk assessment; Supporting File S2. Pesticides in my Smooth Bowl – Part 2 Ecological risk assessment) and Part 3 (human health risk assessment; Supporting File S3. Pesticides in my Smoothie Bowl – Part 3 Human risk assessment) to further learn factors considered during risk assessment and steps in risk determination. Scaffolded questions guide students through the complex process of interpreting toxicity and exposure endpoints, choosing appropriate endpoints for risk calculation, and comparing risk to reference levels for risk determination. A table is provided at the end of both sections for students to incorporate the endpoints they select to calculate risk and reach a conclusion. In Part 4 (Supporting File S4. Pesticides in my Smoothie Bowl – Part 4. A peek into pesticide monitoring data) of the lesson, students have an opportunity to “get a taste” of an authentic dataset and appreciate the vast amount of information scientists often work with, unlike the relatively small datasets students normally see in class. Students first need to read a supplemental document to understand what the columns in the dataset refer to before they can process the data properly. They learn how to use the “sort and filter” function to organize data and locate particular subsets of data for calculating basic statistical parameters in Excel. Finally, they practice these skills by completing a task in which they choose a food item and a pesticide of interest and determine if products from different countries contain different levels of a particular pesticide. Overall, we hope this teaching activity will improve student understanding of risk and risk assessment and perhaps better prepare students who wish to pursue professional careers in toxicology and risk assessment.

Intended Audience

This case study was intended for upper-level college students taking environmental toxicology or other environmental science related courses. However, it can be modified to be suitable for introductory level environmental and biological science students.

Required Learning Time

A two-week period with approximately 2.5 to 3 hours of class time each week.

Prerequisite Student Knowledge

For students, we recommend foundational mathematics and arithmetic as well as basic understanding of descriptive statistics (i.e., mean, standard deviation, and standard error). Preferably, students should also have some background knowledge on environmental contaminants especially how they may exert adverse effects on environmental and human health. Such knowledge, however, is not critical because even non-biology or non-environmental science students can often

learn such information quickly through life experience and some reading. Instructor can assign the ToxTutor module on risk assessment prior to the lesson to ensure that students have a good understanding of the key concepts. Prior experience with Microsoft Excel or Google Sheets is also helpful for completing Part 4.

Prerequisite Teacher Knowledge

In addition to the prerequisite student knowledge, instructors are expected to have experience teaching environmental science related courses or topics. If such experience is not available, instructors should at least have some knowledge of environmental contamination, principles of risk assessment, and factors involved in risk assessment (e.g., toxicity, exposure, uncertainty, etc.). Some good sources for such information are the U.S. EPA and the ToxTutor module on risk assessment. The case study itself also provides some of the background information. More details regarding the malathion risk assessment and risk assessment in general can be obtained from the EPA risk assessment document (1).

SCIENTIFIC TEACHING THEMES

Active Learning

Different from the traditional lecturing method, students go over the handouts (Supporting Files S1-4) and learn by reading the relevant information and answering questions. The questions allow students to promptly evaluate their understanding and correct any misconceptions. Students then apply their knowledge of endpoint selection, risk quotient (RQ), uncertainty factors, and risk determination to evaluate the risk of malathion for ecological and human health. Working in groups allows students to interact with their peers, exchange ideas, and discuss difficult concepts. Using authentic datasets and scenarios, this case study provides an opportunity for students to get experience handling real-world data. We also created dialogues of fictional characters to introduce topics of pesticides and risk assessment. These conversations discuss topics such as food, wildlife, pesticides, risk, etc., and may resonate with and engage students in learning about risk assessment.

Assessment

Questions and tasks are provided through the case study that allow students to learn, practice, and test their understanding promptly. Therefore, students are primarily assessed by their responses to pre-class and in-class formative assessment questions, discussion questions, and an end-of-section exercise for each part. For Parts 2 and 3, the risk determination tasks allow students to apply what they have learned to select appropriate toxicity and exposure endpoints and determine risk and draw conclusions. Similarly, students will select a sub-dataset of interest and conduct statistical analysis in Part 4.

Inclusive Teaching

The lesson introduces risk assessment through conversations between three friends about pesticides in food. Because food is such an integral part of everyday life, this introduction provides an interesting start point for all students to explore the lesson and learn about risk assessment. Additionally, students have an opportunity to select pesticides and foods of

their interest to investigate in Part 4. This will allow students of different backgrounds to participate in the lesson based on their preference for food and pesticide. This lesson requires a computer, Microsoft Excel, and an Internet connection, which are readily available even in institutions with limited resources. Due to the recent transition to online learning, schools normally provide free computers and WiFi hotspots as well as computer labs on campus, which allow students to complete online coursework. If free Microsoft Excel is not available, students can use Google Doc and Google Sheet (free with a Gmail account) to view the lesson and the dataset and complete data analysis. We also recommend think-pair-share or group work while going through the questions to encourage participation of students who may struggle with the questions.

LESSON PLAN

Summary

The lesson consists of four parts: (1) a pre-class assignment, (2) ecological risk assessment, (3) human risk assessment, and (4) reviewing a large dataset of pesticide monitoring data in various food items. In the pre-class assignment, students explore the meaning of “organic,” common types of pesticides, and the difference between hazard and risk. In Part 2, scaffolded questions are provided to guide students through the steps of selecting appropriate toxicity and exposure endpoints to calculate RQ. Part 3 focuses on risk assessment for human health, which utilizes similar principles as ecological risk assessment but may appear more complex. Students learn adjustments of toxicity endpoints to account for uncertainty and sensitive populations. Part 4 presents authentic monitoring data of pesticides in food from the U.S. Food and Drug Administration (FDA) and provides an opportunity for students to practice handling large datasets which are common in the real world. This lesson is designed for a two-week class period with about 2.5-3 hours of instructional time per week to cover most of the key steps in screening level risk assessment for pesticides typically conducted by regulatory agencies such as the EPA. However, instructors can modify the lesson and/or choose the parts that align with their teaching objectives. For example, if data analysis and quantitative skills is not the focus of the course, Part 4 can be excluded, and more instructional time can potentially be spent on other parts for more in-depth learning.

Preparation

We recommend using a Learning Management System (LMS) to house and distribute all the documents of this lesson to students. Create a folder and upload all parts of the lesson (Supporting Files S1-S4). In the same folder, set up the pre-lab assignment in the quiz format to collect responses and to hold students responsible for completing the assignment before class. As there are dialogues and other non-question information in the pre-lab assignment, include only the actual questions in the quiz without the additional reading material. Instruct students to read the handout and then submit their answers by completing the quiz. Posting the questions as a quiz in the LMS allows for easy tracking of student completion and quick grading as the multiple-choice questions can be graded automatically. Additionally, the LMS can often generate a report on student responses for each question

which is valuable to assess student understanding. For Parts 2-4, instructors can print out hard copies of the handout or make sure students have access to a computer.

Part 1: Pre-Class Assignment

Assign the pre-class section prior to in-class activities so that students have some background knowledge on pesticides and some of the factors involved in risk calculation. The dialogue between the fictional characters touches on some controversial and debated topics among the public including food safety, ecological impact of pesticides, and organic food. The questions in this section are designed to make students ponder these topics and stimulate their interest in evaluating pesticide safety to humans and other organisms. If instructors have time to cover this section in class rather than assigning this as a pre-class assignment, it may be fun and engaging to have students act as the characters.

Questions 1-3 prompt students to research organic food. Students often have little knowledge or even misconceptions about what the term “organic” entails. Federal guidelines stipulate what can be called “organic” and one of the requirements is that there is no application of synthetic pesticides to the soil (for three years), crops, or feed for livestock. Unlikely naturally occurring substances, synthetic pesticides are artificially manufactured and are often potent and exert greater adverse effects to environmental and human health. When reviewing student answers for these questions, encourage students to discuss what they know before and after the assignment about what constitutes organic.

Risk is determined by severity of the hazard and how likely the particular hazard may occur. As discussed in the dialogue between the fictional characters, something that is less hazardous but occurs more often may be riskier than those that have a more severe consequence but rarely happens. In chemical risk assessment, we have to consider the hazard (i.e., toxic effect) and likelihood of occurrence (i.e., possible concentrations that organisms encounter). It is key to make sure students correct any misconceptions about risk in risk assessment before moving on to Part 2. After students have a better understanding of risk, they learn the definition of chemical risk from the EPA website (Q7) and factors considered in risk assessment (Q8). The student handout provides detailed information on terminology, including RQ and common acute and chronic toxicity data collected for risk calculation. Students then answer Q9 and Q10 to test their understanding of RQ and common endpoints. Question 11 emphasizes that chemical exposure can occur in various routes, all of which need to be considered during risk assessment. Students learn the frequent need to adopt model-generating exposure levels in determining risk in Q12 and Q13. Table 1 introduces some common model organisms used in toxicity testing, and prompts students to think about variations in test durations related to taxonomic groups in Q14, as well as the common practice to assess short-term and long-term toxicity.

If this section is assigned pre-class, spend about 15 minutes at the beginning of the class to review the questions in this section before letting students work on Part 2. It is possible that it may take longer to review this section if students are interested in discussing organic food and risk.

Part 2: Ecological Risk Assessment

Through scaffolded questions, Part 2 walks students through a mini ecological risk assessment for malathion during the pesticide re-registration process and introduces students to the steps of a typical pesticide ecological risk assessment. All the data used in this section are real data from a pesticide re-registration review document for malathion. As there are many new terminologies and concepts in this section, it may be better to break this part into two shorter subsections consisting of questions of related topics. We recommend giving students time to finish one subsection and then review the questions rather than let students finish the entire section and then go over answers. This makes the relatively long Part 2 more manageable to students and helps reduce the chances that students get distracted while working on the problems. We suggest dividing this section to the following subsections (instructors can modify as they see fit).

Subsection 1: Questions 15-19

Questions 15, 16, and 17 test student understanding of the relationship between toxicity endpoints and a chemical's toxicity, and the relationship between toxicity endpoints and species sensitivity to a chemical. Keep in mind that a lower toxicity endpoint indicates higher toxicity. It is often hard for students to grasp this concept. An example can be given to help students understand: Chemical A has a LC50 of 0.1 mg/L and Chemical B has a LC50 of 1 mg/L. Based on the LC50 data, we know that 0.1 mg/L of Chemical A kills 50% of test organisms whereas it requires 1 mg/L of Chemical B (10 times the amount of Chemical A) to kill 50% of the same test organisms. In other words, it takes less of Chemical A to kill the same number of individuals than Chemical B. Therefore, Chemical A is more toxic than Chemical B. Similarly, a species with a lower toxicity endpoint of a particular chemical (e.g., LC50 or LD50) is more sensitive to this chemical than another species with a higher toxicity endpoint. With such knowledge, students will be able to choose the most conservative (i.e., protective) endpoints and species when calculating the RQ later in this section.

Once a RQ is calculated, it is compared to the EPA's Level of Concern (LOC) and Risk Presumptions provided in Table 2. Students think about why LOCs for endangered and threatened species are lower than non-listed species in Q18. Question 19 is a good practice for students to use available data to calculate the RQ and compare it to LOC to determine if there is any potential risk.

Subsection 2: Questions 20-29

The rest of Part 2 breaks the fairly complicated process of ecological risk assessment down into simplified steps. Students learn important concepts related to toxicity and exposure, the two key parts of a risk quotient. Questions 20-22 are about choosing protective toxicity endpoints to protect more sensitive organisms. This is another test of student understanding of the relationship between toxicity endpoints and species sensitivity introduced in Q15-17.

Questions 23-27 guide students through the process of selecting appropriate exposure endpoints. There are commonly three exposure estimates available including a 21-day average, a 60-day average, and a peak concentration. Q23 and 24 prompt students to interpret the exposure data

and select exposure values that are most protective. Another factor to consider when selecting appropriate exposure values for RQ calculation is that the exposure endpoint should also be appropriate for the model organism. For instance, the 21-day average should be used to calculate chronic RQ for aquatic invertebrates that do not have a long lifespan, whereas a 60-day average is appropriate for calculating chronic RQ for fish. Questions 25, 26, and 27 are designed to help students understand such concepts. At the end of the section, students fill out the risk table in Q28 and determine RQs and provide their conclusion in Q29. If time is running out in class, these two questions can be assigned as homework and instructors can spend a few minutes to go over the answers in the next class session.

Part 3: Human Health Risk Assessment

The final section takes the process of risk assessment learned in Part 2 and applies the same general principles to human health risk assessment. This part begins with another discussion among the fictional characters about whether pesticides in food may affect human health and how food safety is ensured by government agencies through risk assessment. Many of the concepts in human risk assessment are similar to ecological risk assessment, but here students are introduced to the concept of uncertainty factors to create conservative estimates of risk when that approach is warranted (as we do with human health risk assessment). Question 30 allows students to expand what they know about exposure routes from Part 2 and consider more exposure routes in human risk assessment due to the complexity of human activities. Question 31 brings up a common scenario risk assessors face regarding selection of sex when conducting mammalian toxicity testing for human risk assessment. Students learn about the potential higher sensitivity of females due to reproduction and body mass.

Questions 32-34 are designed to introduce the inter- and intra-species variations when using non-human test species and how such uncertainty is accounted for in human risk assessment using the uncertainty factor (UF) and margin of safety (10x in the case of malathion). Question 35 and 36 then ask students to apply these adjustment factors to derive a Population Adjusted Dose (PAD). The PAD, similar to the toxicity endpoints in ecological risk assessment, is used along with the exposure endpoints to estimate the risk. The process of obtaining toxicity endpoints for human risk assessment is more complex than ecological risk assessment. But once students understand the need to adjust the toxicity endpoints to account for interspecies extrapolation and intraspecies variations, the PAD is basically the value after the original toxicity endpoints is adjusted twice by the UF and the margin of safety, respectively.

The handout then introduces risk calculation and reference levels for human risk assessment. Similar to an ecological RQ, risk is also calculated by dividing the exposure by the PAD. However, instead of comparing the risk value directly to levels of concern as in ecological risk assessment, risk for human health should be converted to a percentage value which is then compared to pre-determined LOC of 100%. In another word, risk is presumed if the exposure level is equal to or greater than the PAD.

Students often get confused by the “directions” that are an inherent part of the process. For example, as mentioned in Part 2, counterintuitively, a lower LC50/NOEL/BMDL etc. means the compound is more toxic rather than less toxic. If they have this relationship backwards in their minds, then their uncertainty factor correction will also be backwards, so it is recommended to stop and check that this understanding of toxicity is correct before going into the uncertainty factor corrections. Anytime an uncertainty factor or a safety factor is applied, the original toxicity endpoint should always be divided by the uncertainty factor to generate a lower new endpoint which is more conservative and protective.

Another challenge many students may face is the presence of many terms used as toxicity endpoints for human risk assessment and how these terms are related to one another. We have created a flow chart (Figure 1) to help instructors and students develop a better picture of how these terms are calculated and applied in the risk assessment process. Please note that the flow chart only includes the terms mentioned in this particular risk assessment for malathion.

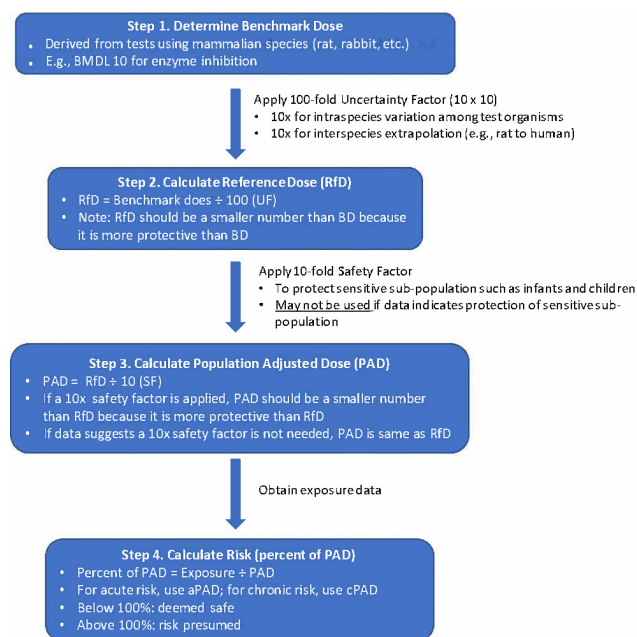


Figure 1. A schematic of common steps in determining pesticide risk to human health.

As reported previously, there is great potential for enriched discussions in this section. In the beginning, Q32-34 all offer opportunities to discuss aspects of the use of surrogate species and/or how we generate information about toxicity without performing experiments on people (which is generally considered morally unacceptable). Finally, as you reach the end of this case study, we strongly suggest asking students to reflect on what they have learned and how their view of pesticides, regulation, and risk have changed over the course of this case study. Some of the closing questions provide great “bookend” discussions that can be combined with similar discussions that happen at the beginning of the case study based on students’ answers to the pre-class questions.

Part 4. A Peek into Pesticide Monitoring Data

This section is not meant to provide an extensive and in-depth look into data analysis and interpretation. Instead, it is designed for students to have an opportunity to see the scale and quantity of real-world monitoring data conducted by government agencies. Give students a few minutes to open the data file and glance through the data. In Q41-43, students practice reading a data file and especially using supplemental information to identify the various components in the data file, which is important for correctly interpreting data. If this is the first time that students have dealt with ppm (parts per million) and ppb (parts per billion), take a few minutes to go over the units and make sure students convert between the two units correctly in Q42 (f). Question 44 shows students a few features in Excel that facilitate data viewing and sorting. In Q45, students follow instructions to locate the data of interest and conduct a t-test to compare two groups of data. They present the data using a bar graph to show the mean with standard error. Question 46 is an exercise where students select any data they are interested in and perform data organization and analysis.

TEACHING DISCUSSION

At the beginning of Class Session 1 when reviewing the pre-class assignment, have the students discuss what they thought about pesticides previously (if at all). It is an interesting teachable moment to correct the common misconception of what the term “organic” means. Many students will assume it means food grown without the use of any chemicals (which is incorrect). This generates a really engaging discussion that sets the tone for the rest of the case study and in our experience does a good job of grabbing student attention to the topic.

In Part 2, students learn how to properly evaluate risk. People (students and adults alike) are generally poor at assessing risk. We think nothing of performing risky behaviors daily (like driving in our car), but then might have fears regarding perfectly safe activities (like riding a roller coaster, removing a spider from the house, or flying in a plane). It is important to point out these blind spots because it can skew our understanding of risk. Chemicals can easily fall into that category of things we fear when there is no reason to do so (or alternatively we can be accustomed to ingesting foods without considering potential risks).

Additionally, there can be a good discussion towards the end of Part 2 when the students find there is potential for risk from the cotton applications. You can ask students questions to extend the knowledge they have learned: What can be done to mitigate the potential risk found here? What other information would you like to have to make a decision to approve or deny this pesticide? What level of risk is acceptable?

In Part 3, it may be helpful to show students the human risk assessment flow chart created for instructors. Some students will be confused about the multi-step adjustment for uncertainty. The flow chart provides a visual guide on the entire process. Instructors can also ask students to make their own flow chart. More time should be given to students if they need to create the flow chart.

For the data analysis in Part 4, instructors can modify as needed. For instance, replace the t-test with ANOVA and have students compare three or more questions if the data allow. Similar to the t-test, there are online ANOVA calculators available for students who use Google Sheets or have trouble installing the data analysis package in Excel.

One note about the data presented in the lesson. It is important that students do not walk away from this class thinking that malathion is an extreme environmental risk. The ecological risk assessment process described here is a very conservative one with many built-in assumptions that increase perceived risk. It might be worth pointing out to students that the risk assessment process has 4 tiers and at the 1st tier (essentially what is being presented in Part 2), estimates of exposure are extreme and toxicity estimates used are “worst case scenarios.” If a chemical/pesticide fails at any particular tier of the process, it moves up to a higher tier that is more specific to that pesticide’s applications and more realistic in terms of exposure and toxicity estimates (when possible). Malathion is not without risk but has been used for decades without wiping out entire aquatic invertebrate communities.

SUPPORTING MATERIALS

- S1. Pesticides in my Smoothie Bowl – Part 1. Pre-class assignment
- S2. Pesticides in my Smoothie Bowl – Part 2. Ecological risk assessment
- S3. Pesticides in my Smoothie Bowl – Part 3. Human risk assessment
- S4. Pesticides in my Smoothie Bowl – Part 4. A peek into pesticide monitoring data
- S5. Pesticides in my Smoothie Bowl – Answer key

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Table 1. Teaching timeline table

Activity	Description	Estimated Time	Notes
Preparation for Class			
Assign the pre-class assignment and grade student answers	1. This pre-class activity can be assigned by setting up a pre-class quiz in the Learning Management System (LMS). Grade student answers before the Class Session 1. 2. Assign students to groups of 2-3 students, if grouping needs to be done prior to class. 3. Remind students to bring a computer or a hard copy of the case study to the next class.	Prep time for instructors: 20-30 minutes to set up the assignment in LMS Completion time for students: ~30-40 minutes	We suggest setting up the assignment in the LMS by converting all questions to an open-book quiz format. It makes it easier for students to complete and for instructors to grade and track student performance.
Class Session 1			
Pre-class assignment	Review student answers for the pre-class assignment questions.	~15 minutes	1. While going over the questions, make sure to address any misconceptions and misunderstandings reflected in student answers. 2. Students often show great interest in organic food and what risk entails. Prepare to have a few extra minutes for this activity if students are engaging.
Part 2 of the lesson	Have students work in groups to go over the handout and answer the questions in this section.	~40-50 min (student work time) ~30-40 min (instructional time)	1. If possible, keep groups small (2-3 students per group) to promote participation. Encourage students to work on their own to answer all the questions and then discuss with others. Check in with each group periodically to answer any questions that may arise. 2. Instead of having students finish all the questions and reviewing the answers all at once at the end, we recommend breaking the questions to two parts and go over the answers after students finish each part: • Questions 15-19 • Questions 20-29 (Questions 28-29 can be assigned as homework if time runs out.)
Class Session 2			
Part 3 of the lesson	Have students work in groups to go over the handout and answer the questions in this section.	~40 min (student work time) ~30-40 min (instructional time)	1. Continue to have students work in groups. 2. As this part has fewer questions and questions are all related to the same topic, instructors can decide whether to break it into smaller sections or not.
Student pre-class preparation for Part 4	Prior to Class Session 3, remind students to bring computers to next class and install Microsoft Excel on their computers or make sure they have access to Google Sheets.		1. Instructors may want to assign the video tutorial on how to make a bar graph in Part 4 Question 45 (d) as a pre-class homework. 2. Instructors need to make sure that students have WiFi connection for Class Session 3. Some students may have to use Google Sheets and online statistical calculators to analyze data. 3. Alternative to having students bring their computers, instructors can use a computer lab for Class Session 3.
Class Session 3			
Part 4 of the lesson	Students complete the activities using the handout	~1 h (student work time) ~30 min (instructional time)	1. Continue to have students work in groups. 2. Check in on each group frequently as students often run into issues with Excel or have questions about how to use specific functions in Excel. 3. All of the questions can be answered using Google Sheets if students cannot access Excel for free.