

High School Lesson Plan: Methods in Scientific Inquiry

Lesson Title: Analyzing Chlorine Decay Using EPANET

Instructor: Jane Proszek Gorninski

Grade Level: High School (Grades 10–12)

Duration: 2–3 class periods (50 minutes each)

Lesson Overview

Students will be introduced to EPANET, a software application used to simulate water distribution systems. In this lesson, students will learn how to navigate the interface, explore the types of analyses EPANET enables, and conduct simulations to understand chlorine decay in a water treatment network. The lesson includes theoretical context, collaborative analysis, and data-based conclusions.

Lesson Objectives

- Navigate and operate EPANET software
- Identify and describe the variables analyzed in water distribution systems
- Analyze chlorine decay across different network locations and times
- Use mathematical equations to simulate temperature-based decay rates
- Collaboratively interpret data and draw scientific conclusions

Standards Addressed

- NGSS HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem.
- NGSS HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature on reaction rates.
- CCSS.MATH.CONTENT.HSF.IF.C.7: Analyze functions by building and interpreting them.

Materials

- Computers with EPANET pre-installed
- EPANET input file (.inp) of a water treatment system (provided by instructor)
- Student worksheets
- Calculator

Theoretical Framework

Water Distribution and Treatment

- Components of a water distribution system (reservoirs, tanks, pipes, junctions)
- Role of chlorine in water treatment (disinfection and safety)

Chlorine Decay

- First-order decay kinetics: $C(t) = C_0 * e^{(-kt)}$
- Factors affecting chlorine decay: temperature, time, pipe material, flow rate

Environmental Simulation

- Use of EPANET as a digital tool for modeling water systems
- Benefits of modeling to predict water quality under varying conditions

Lesson Procedure

Day 1: Introduction & Software Orientation

- Bell Ringer (5 min): Quick discussion on importance of clean water
- Presentation & Discussion (15 min): Introduction to EPANET and overview of chlorine decay
- Software Tutorial (30 min): Guided navigation and loading .inp file

Day 2: Data Collection & Analysis

- Group Setup (5 min): Assign pairs and distribute materials
- Simulation Tasks (40 min): Run simulations at 24, 48, 96, 240 hours
- Variable Analysis (5 min): Group discussion of trends

Day 3: Temperature Simulation & Conclusion

- Mathematical Analysis (15 min): Use decay equations for 5°C and 25°C
- Graphing & Interpretation (20 min): Plot and analyze decay curves
- Class Discussion (10 min): Key takeaways and real-world relevance
- Exit Ticket (5 min): Summary of insights and remaining questions

Active Engagement & Modern Teaching Methods

- Think-Pair-Share: Before running the simulation, ask students to discuss in pairs how they expect chlorine to behave over time in a water system.
- Interactive Simulation Walkthrough: Use a projector to walk through EPANET tasks live, pausing to let students follow along and ask questions.
- Visual Learning: Encourage students to use color-coded maps in EPANET to track chlorine concentrations across the system and identify patterns.

- Hands-On Exploration: After guided tasks, allow students to manipulate pipe lengths, flow rates, or add new junctions to observe how system changes affect outcomes.
- Peer Teaching: Have students present their decay curve graphs and findings to their peers, encouraging public speaking and peer feedback.
- Real-World Connections: Facilitate a class discussion connecting their findings to public health issues or case studies of water quality crises.
- Digital Collaboration: Use shared online documents (e.g., Google Docs) for students to log data, compare results, and co-write conclusions.
- Gamification: Create a challenge to identify the most stable area in the system based on chlorine retention, promoting healthy competition.

Assessment

- Participation in group simulation work
- Completion of worksheet with data tables and analysis
- Exit ticket reflection
- Optional: short quiz on chlorine decay and EPANET use

Extension Opportunities

- Students design their own simple EPANET network to optimize chlorine distribution
- Research project on real-world water quality issues and present findings

References

- U.S. EPA EPANET Software: <https://www.epa.gov/water-research/epanet>
- AP Environmental Science Curriculum Framework
- WHO Guidelines for Drinking-water Quality
- Online EPANET user manuals and YouTube tutorials

Notes for Instructor

- Ensure all software is installed and tested before the lesson
- Monitor group work to support students unfamiliar with modeling software
- Differentiate tasks by assigning more or less complex analysis depending on group proficiency

Student Grouping

Students will work in pairs to encourage collaboration and problem-solving.

Lesson Plan Organogram

The diagram below illustrates the structure and main activities for each class session in a visually intuitive format.

