Oxbow
Soil Vitality:
Is it healthy?

Student Scientists

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Glossary

Industrial waste (in **dus** tre ul wast): Waste created in the process of manufacturing products.

Agricultural chemicals (**ag** ruh kul chür ul **kem** uh külz): Chemicals used in agriculture. These chemicals can come from a variety of sources such as pesticides, fertilizers, and veterinary medicines.

Chemical property (**kem** uh kül **prôp** ür te): A characteristic of a substance that becomes evident during a chemical reaction. An example is the formation of rust.

∑: This is a symbol that means "the sum".

Physical property (**fiz** ul kül **prôp** ür te): A characteristic of a substance that can be observed, such as color, taste, texture, and density.

Oxbow (**ox** bo): A U-shaped bend in a river or stream.

Nitrogen (**nit** ro jen): Nitrogen is an element that is necessary for plant and animal growth. For example, nitrogen is a part of chlorophyll that plants need for photosynthesis.

Potassium (po **täs** e um): Potassium is an essential mineral that helps with photosynthesis, the quality of fruit, and disease reduction.

Phosphorous (**fôs** fôr us): Phosphorous is an essential nutrient for plant growth. It helps plants with photosynthesis, plant structure, and energy.

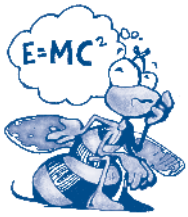
Density (**den** su te): The amount of matter in a given space.

Pronunciation Guide

a	as in ape
ä	as in car
e	as in me
i	as in ice
o	as in go
ô	as in for
u	as in use
ü	as in fur
oo	as in tool
ng	as in sing

Accented syllables are in **bold**.

Thinking About Science



Scientists sometimes develop an index to help them describe and compare a particular thing. An index contains a lot of information summarized into one number or quality. In this research, the student scientists adapted an index created by the Forest Service to describe soil quality. The Forest Service index contains many separate measurements of different soil qualities. The different measures are added together into one number, which represents the quality of a particular soil. Another index you might know about is a credit score. This is one score that represents many measures of a person's payment record on a variety of loans, such as car loans. One advantage of an index is that it allows scientists to compare one person or thing with another.

Thinking about the Environment

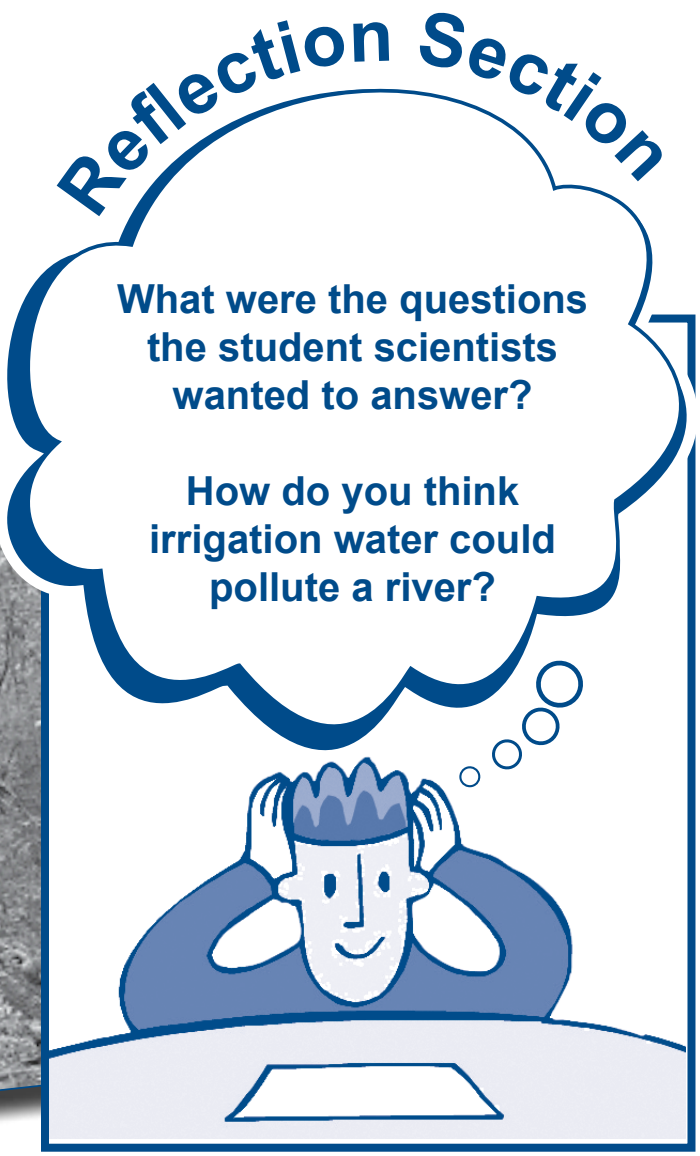
The importance of soil quality is often overlooked when people think about the environment. Soil, however, is the place where plants such as trees, flowers, and crops, get their nutrients. The soil can be depleted of nutrients by years of agriculture. Healthy soil can be washed into streams and rivers. Soil can be polluted by **industrial waste** or **agricultural chemicals**. The student scientists in this study decided to investigate the soil quality in an area near their school. They heard that the soil was polluted by irrigation water. They decided to find out for themselves how healthy the soil was in that area.

Introduction

The Forest Service's Forest Inventory and Analysis (FIA) program uses a number of **chemical** and **physical properties** to measure the health and/or quality of soil. A new index was developed that integrates nineteen different measured chemical and physical properties that can be found in soil. The index combines the properties into one single number that serves as the soil's "vital sign." This new index is called the Soil Quality Index (SQI). The SQI is a measure that can be used to describe the **Oxbow's** soil health.

The Oxbow is a 20–acre tract of undeveloped land, bound on three sides by an oxbow of the Rouge River in Dearborn, Michigan **(figure 1)**. The Oxbow has been contaminated and ruined over time. The water is (partially) polluted by irrigation. Our job, as the soil team, was to find out how the soil has been affected by irrigation water and determine the overall status of the soil's health in the Oxbow.

Figure 1. The Oxbow, Dearborn, Michigan.



Method

Our student team used a modification of the SQI to measure the health of soil in the Oxbow. Soil properties were measured in the Oxbow area of Greenfield Village during the week of November 28, 2007. The Oxbow has many different trees from hackberries to white oaks. Our team chose three trees to be the main independent variables in our research **(figure 2)**. These three trees are the ash, hackberry, and cottonwood. We chose these trees because they are dominant in the Oxbow.

Our team hypothesized the following:
"If the tree is healthy, then the SQI value will be higher; and if the tree is unhealthy, then the SQI value will be lower."

Since we are student scientists, we could not use all of the exact chemical and physical properties that are used to find SQI. We had to create our own SQI value using the same methods with different measured chemical and physical properties. We called our SQI the Student SQI, or SSQI. The original properties that are used to find a SQI are density, soil pH, organic carbon (in minerals) percentage, total nitrogen, sodium, potassium, magnesium, iron, nickel, copper, zinc, cadmium, lead, sulfur, and Bray 1 or Olsen extractable phosphorous.

The only physical and chemical properties that we used were **density** (of gathered soil in percentage), total **nitrogen** (percentage), **potassium**, **phosphorous**, and soil pH. The maximum value of the total SSQI is 9 and the minimum value is -2, if all the 5 properties are measured to their highest and/or lowest level. The SSQI value is then expressed as a percentage. The method that will be used to find the SSQI value is shown in figure 3 and 4.

Figure 2. Experimental Factors in the Oxbow SQI Experiment.

Independent Variable	Factor that changes	Tree Soil
Dependent Variable	Factor that changes due to independent variable	SQI Value
Control	The experiment is compared to this	Average Healthy Soil SQI Value
Constants	Remains the same	5 physical and chemical properties

Figure 3. The properties measured and method used to calculate SSQI.

Property	Level	Interpretation	Value
Density (g/cm^3)	>1.5	Possible adverse effects.	0
	≤1.5	Adverse effects unlikely.	1
Soil pH	<3.0	Severely acid-almost no plants can grow in this environment.	-1
	3.01 to 4.0	Strongly acid-only the most acid tolerant plants can grow in this pH range.	0
	4.01 to 5.5	Moderately acid-growth of acid intolerant plants is affected depending on levels of acid.	1
	5.51 to 6.8	Slightly acid-optimum for many plant species, particularly more acid tolerant species.	2
	6.81 to 7.2	Near neutral-optimum for many plant species except for those who prefer acid soils.	2
	7.21 to 7.5	Slightly alkaline-optimum for many plant species except those that prefers acid soils.	1
	7.51 to 8.5	Moderately alkaline-preferred by plants adapted to this pH range.	1
	>8.5	Strongly alkaline-preferred by plants adapted to this pH range.	0

Nitrogen (percent)	>0.5	High-excellent buildup of organic carbon with all associated benefits.	2
	0.1 to 0.5	Moderate-adequate levels.	1
	<0.1	Low-could indicate loss of organic nitrogen.	0
Potassium (mg/kg)	>500	High-excellent reserve.	2
	100 to 500	Moderate-adequate levels for most plants.	1
	<100	Low-possible deficiencies.	0
Phosphorus (mg/kg)	>1000	High-excellent reserve, probably calcareous soil.	2
	101 to 1000	Moderate-adequate levels for most plants.	1
	10 to 100	Low-possible deficiencies.	0
	<10	Very Low-severe Ca depletion, adverse effects more likely.	-1

Figure 4. Equations used by the student scientists.

$$\text{Total SSQI} = \Sigma \text{ individual soil property values}$$

$$\text{SSQI} = (\text{Total SSQI} / \text{Maximum possible total SSQI for properties measured}) \times 100$$

The team gathered six different samples from the three different trees chosen **(figure 5)**. Although we decided to use only three trees, we wanted to have multiple samples from each tree. We took two different samples for each tree. Two samples were taken from two different ash, hackberry, and cottonwood trees. The next step was to find the properties listed above. After finding these properties we were able to conclude the SSQI value of each sample of the soil. We were hopeful that we would come up with an average SSQI value of the entire Oxbow, or portion of the area.

Figure 5. The team gathered different soil samples from under three different tree species.

Reflection Section

Why did the student scientists have to modify the SQI?

Why did the student scientists focus on ash, hackberry, and cottonwood trees?

Findings

The results of our soil analysis varied depending on the area from which the soil was taken. We assumed the soil was healthy since it was taken from around tree roots. In some areas, the soil was higher in certain nutrients (chemical properties) and low in others. Our data states the SSQI value of each area of the Oxbow, and an average SSQI value for the entire region of the Oxbow. The physical properties of our soil samples consisted of measures of potassium, phosphorous, nitrogen, and soil pH **(figure 6)**.

From the results of our experiment, we estimated that the soil quality of the Oxbow is measured to a value of 5. The total SSQI range is from 3-6. The average is 4.5. The SSQI value ranges from 33.33-66.67 and averages 50.00.

This says a lot about the soil vitality of the Oxbow. It is not necessarily healthy, but it also isn't dangerous. The pH levels show that the Oxbow is suitable for plants to live there, and plants actually prefer the soil pH of the Oxbow. However, the Oxbow is low in nitrogen and high in potassium. Plants that need potassium would prefer to live here as well. Though the soil is low in nitrogen with high nutrients in other chemical properties it shows that trees and other plants are very likely to live in the Oxbow.

Figure 6. The results of the soil analysis.

Hack= Hackberry CW= Cottonwood.

SSQI Factor	Ash Tree 1	Ash Tree 2	Hack Tree 1	Hack Tree 2	CW Tree 1	CW Tree 2
Density	1	1	1	1	1	1
Potassium	Medium 1	Medium 1	Medium 1	High 2	Medium 1	Medium 1
Phosphorous	Low 0	Medium 1	Low 0	Medium 1	Low 0	Medium 1
Nitrogen	Low 0	Low 0	Low 0	Low 0	Low 0	Low 0
Soil pH/ SSQI	8 1	7 2	6 2	7 2	7 2	6 2
Total SSQI	3	5	4	6	4	5
SSQI Value	33.33	55.56	44.44	66.67	44.44	55.56

Reflection Section

In your own words, summarize what the student scientists found through their study.

The SSQI value ranges from 33.33-66.67. The average is 50.00. Based on these findings do you agree with the students' assessment of their findings? Why or why not?

Discussion

After doing our research and doing an analysis, we came to the conclusion that the soil was in pretty good shape. Therefore, we concluded that the soil was not being affected too much by irrigation water. The soil in some areas had highs and lows but overall the soil in the Oxbow was moderate. This means that some plants can live in the soil. Of course, it would have been good to be able to measure more chemicals.

With all of the work being done to the Oxbow, it is surely on its way from being a dump site to being an attraction for people to come learn about plants and animals alike. The Oxbow has sure seen its bad days, but the light is starting to shine on the forgotten Oxbow.

Reflection Section

The student scientists wished they could have measured more chemicals. If they had been able to do so, do you think they might have come to a different conclusion? Why or why not?

The SSQI used 5 different measures to come up with an overall value. Think of a similar situation in your life where many different measures are combined in some way to produce one overall value. Explore this process of evaluation in a class discussion. What are its advantages and disadvantages?

FACTivity

In this FACTivity, you will do something similar to the student scientists in this study. The question you will answer in this FACTivity is: How do different areas in our school yard compare as wildlife habitats?

The method you will use to answer your question is:

Divide your class into 6 groups. Select three separate areas in your school yard. Depending on the size of your school yard, each area could be rather small. Two groups will work in each area.

Use the Student Wildlife Habitat Quality Index (SWHQI) below.

The range of this index is –2 to 6. Six would indicate an excellent wildlife habitat and –2 would indicate a poor wildlife habitat.

After the groups gather data on different areas in the school yard, compare what you found. What is the wildlife habitat quality overall? What could you do to improve the wildlife habitat? Where some areas of the school yard better than other areas? If so, why?

Discuss the value of using an index to compare wildlife habitats. Is it easier to use one number than comparing five qualities? Why or why not?

PLT

If you are a PLT-trained educator, you may use #70 "Soil Stories" as an additional resource.

Does the area have natural ground cover, such as leaves and small bushes?	**No coverage (less than 10 percent)= -1 Some coverage (less than 25 percent) =0 Fifty percent coverage and above=1**
Are there are variety of plants in the area?	**No variety= 0 Some variety=1 Wide variety=2**
Are there some plants that produce berries or other fruits?	**No plants=-1 Less than 25 percent = 0 Fifty percent and above= 1**
Is there some source of fresh water available?	**No =0 Yes=1**
Is there enough space for things to grow and live?	**No=0 Yes=1**