Water Quality Lab Web Resource Page

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Caveats of using bioindicators?

While the effect of water quality on a bioindicator is often taken as a measure of the overall condition of the ecosystem, this assumption is not always correct. Not all organism respond in the same way to different forms of pollution. The impacts on algae, invertebrates, vertebrates and aquatic plants are likely to be quite different. Organisms may be sensitive to pollutants at different concentration ranges, and some organisms may be entirely unaffected by certain types of pollutants. For example, photosynthetic organisms will be much more sensitive to herbicides running into water ways from agricultural lands, whereas vertebrates are likely to suffer the consequences of an organic pollutant that bioaccumulates in the ecosystem. Even within a group of organisms (among algae, for example) some species are more sensitive than other species to certain pollutants. For this reason, effects on a particular biological indicator cannot be directly extrapolated to other groups of organisms, and using multiple bioindicators is often required for a thorough ecological assessment.

Nevertheless, observing an effect on a particular organism can be of ecological significance, since pollutants rarely affect only a single species. Furthermore, because of the complex interactions (competition, predator/prey, symbiosis) among organisms, impacts on any species or group of organisms is likely to reverberate throughout the ecosystem. If nothing else, an observed effect for a particular bioindicator indicates that further investigation is warranted.

What is activated carbon and why is it used for water purification?

Activated carbon is produced by heating an inexpensive organic biomass material to approximately 600^{O}C in the absence of oxygen. Raw material often used include wood, coal, and nutshells. The result is a material that is essentially pure carbon. The carbon is 'activated' by subsequent exposure to high temperature steam which generates numerous microscopic pores in the carbon particles. The pores create surfaces upon which organic materials can bind. For some forms of activated carbon, the surface area may be 600 - 1600 square meters per gram, the equivalent of 2-5 football fields!!

Activated carbon is the universal absorbent known for organic substances, which bind to the carbon atoms exposed on the pore surfaces. The carbon itself is chemically inert, which makes it ideal for use in both industrial and residential water purification systems. With continual use the binding sites of the activated carbon will become saturated, and the bound organic molecules can only be stripped off the activated carbon at high temperature. For this reason, most home water purification systems use disposable activated carbon cartridges.

Sample literature annotations

These are examples of literature annotations upon which you can model the annotations you prepare for the annotated bibliography assignment.

Annotation example 1 : Primary article

Sáenz, ME, Di Marzio WD, Alberdi, JL, del Carmen Tortorelli, M. 1977. Effects of technical grade and commercial formulation of glyphosate on algal population growth. Bull. Environ Contamin. Toxicol. 59: 638-644.

This paper describes the effects of two forms of glyphosate on algal growth. Glyphosate is a broad spectrum herbicide and the active agent of Ron-do and other commercial formulations. Glyphosate may run off into aquatic ecosystems from lands sprayed with the herbicide. Since algae and plants are both photosynthetic, there is reason to be concerned about the effect of this runoff on aquatic ecosystems.

The effects of glyphosate was tested on two species of green algae, *Scenedesmus acutus* and *S. quadricauda*. The algae were grown in Detmer's nutrient medium under "cool-white" fluorescent lighting on a shaker. Different concentrations of the technical grade glyphosate (95.5% pure) or the Ron-do formulation (48% glyphosate) were added to the algal cultures, which were incubated for up to 96 hours. Growth was determined by measuring the amount of chlorophyll in the cultures and evaluated through the t-test. Percent inhibition of growth, NOEC (no observable effect concentration) and LOEC (lowest observable effect concentration) values were determined.

The researchers concluded that there was a difference in sensitivity between the algal species in response to pure glyphosate but not to the Ron-do formulation. They also suggest that glyphosate runoff into aquatic ecosystems may cause harmful effects on these algal species. These results are pertinent to my study since glyphosate may run off into rivers around Marietta, and because they indicate that different species of algae may show different sensitivity to the same chemical.

[Note to students: As an annotation of a primary literature source, this annotation includes a brief synopsis of the purpose, methodology, results and conclusions of the study, along with a statement of the relevance to the class investigation.]

Annotation example 2: Secondary article

Sures B. 2001. The use of fish parasites as bioindicators of heavy metals in aquatic ecosystems: a review. Aquatic Biology 35: 245-255.

This paper reviews literature on the use of fish parasites as indicators of aquatic pollutions and ecosystem damage. The author cites a study that says there may be as many as 30,000 species of helminthic worms that are fish parasites, and they therefore probably play an important role in aquatic ecosystems. When used as bioindicators, fish parasites can be used as 'effect indicators' or as 'accumulation indicators'. When used as effect indicators, parasites are monitored for presence or absence of a given species, or for changes in the diversity of host-specific parasites. Monogenean species have been used for this purpose, and several studies have investigated how they change in response to paper mill effluent.

Much of the review discusses use of acanthocephalan species as accumulation indicators of heavy metal pollutants. These organisms have complex life cycles, and alternate between crustacean and fish hosts. The adult form of the parasites (in fish) has a high capacity for bioaccumulating pollutants, whereas other parasites, such as the swimbladder nematode show little or no heavy metal accumulation. One study found levels of cadmium to be 400 times higher than in the host fish and 27,000 times higher than in the water. The author stated that these high concentration appear not to be lethal to the adult parasites, but other effects (such as on reproduction) have not been studied. Thus, adult acanthocephalans may be valuable indicators of heavy metal pollution.

The paper includes data from one study that comparing levels of lead and cadmium in parasite and host fish tissues (for several fish species) and from another study that shows uptake of lead in parasites and host tissues over a five week period. This paper is pertinent to the bioindicator lab exercise since it shows how another type of microorganism has been used as a bioindicator, and gives information about the ways in which bioindicators can be used.

[Note to students: Since this is a secondary source, the article presents and discusses information previously published in primary sources. Thus, the annotation gives an overview of relevant topics, and mentions some specific studies that are reviewed. Note also that at the end of the annotation there is an indication of how the paper is relevant to the Bioindicator lab exercise]

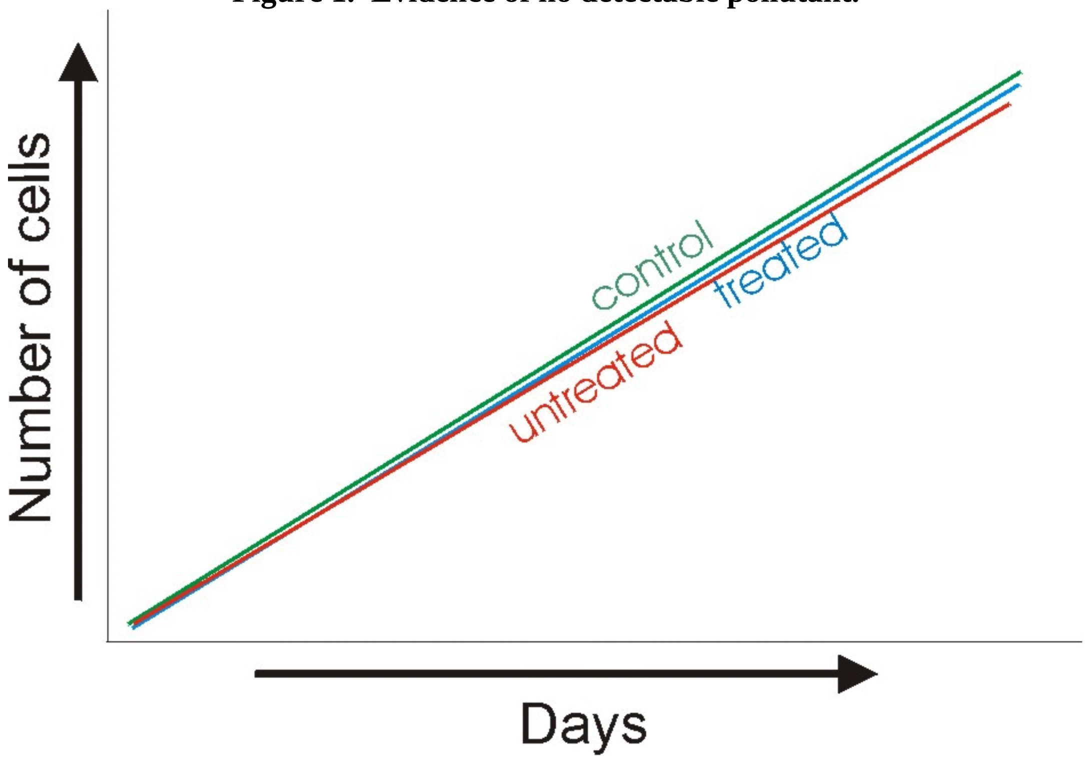
Interpretation of Results

The presence and type of pollutant(s) in the water sample can be deduced from the different growth rates observed for the control (spring water) and activated treated and untreated water samples. Some patterns that might be observed are illustrated in the figures presented below. While these figures present only trendlines to simplify the presentation, your results would also include the data points. These examples represent some idealized patterns, and your results may not clearly match any of these. Indeed, complex interactions between different types of pollutants (e.g., between organic and eutrophying pollutants) might yield some unusual patterns. Nevertheless, you should understand why these patterns might occur and seek to explain your results by applying the same principles.

A. Evidence of no detectable pollution.

Uncontaminated water should have no effect on the growth of *Pseudokirchneriella*, in which case you would expect to see no significant difference in the growth rates between the control and river water samples, as illustrated in Figure 1. While it is reasonable to assume that local river waters contain a variety of organic contaminants, their presence may not be detectable in this bioassay. On one hand the concentration of the pollutants may be lower than that necessary to inhibit growth of *Pseudokirchneriella*. Alternatively, *Pseudokirchneriella* might be insensitive to the particular type of pollutant(s) that may be present. How might you design an experiment to test for these alternative explanations?

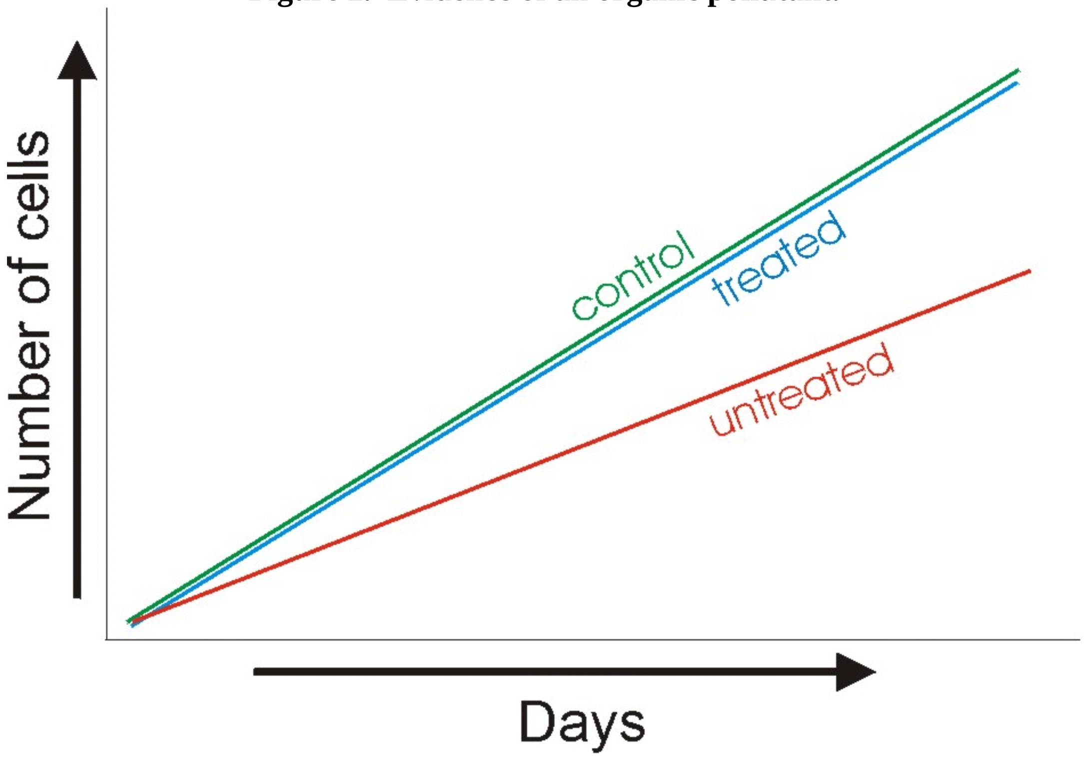
Figure 1. Evidence of no detectable pollutant.



B. Evidence of an organic pollutant.

If an organic pollutant is present in the water of a type and concentration that inhibits growth of *Pseudokirchneriella*, its removal should also reduce inhibition of algal growth by the water sample. Idealized cell growth patterns in this scenario are shown in Figure 2. The extent to which the treatment reduces inhibition depends upon a number of factors. If the pollutant does not bind strongly to activated carbon or is present at very high levels, then it may not be effectively removed and inhibition may still occur. How might you design an experiment to test for these alternative explanations?

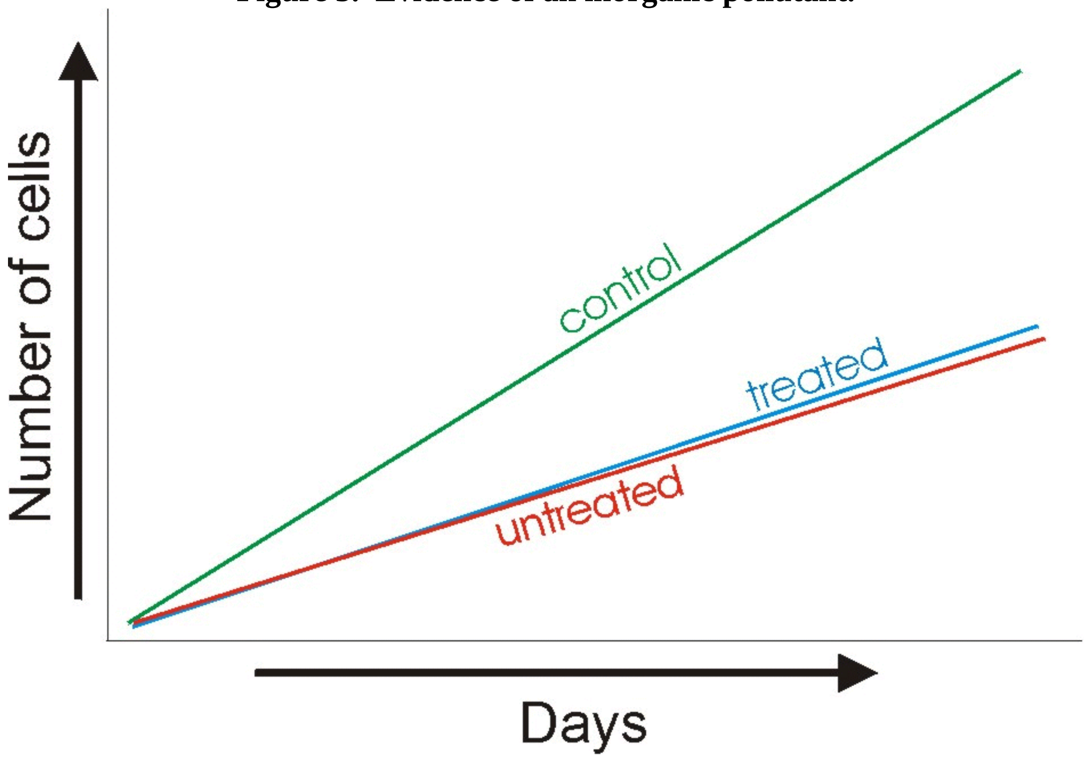
Figure 2. Evidence of an organic pollutant.



C. Evidence of an inorganic pollutant.

If treatment with activated carbon does not reduce inhibition of algal growth by the water sample (as illustrated in Figure 3), then possibly the pollutant is inorganic. While it is possible that the pollutant is organic and does not bind to activated carbon, such pollutants are relatively uncommon. How can inorganic pollutants be removed from water?

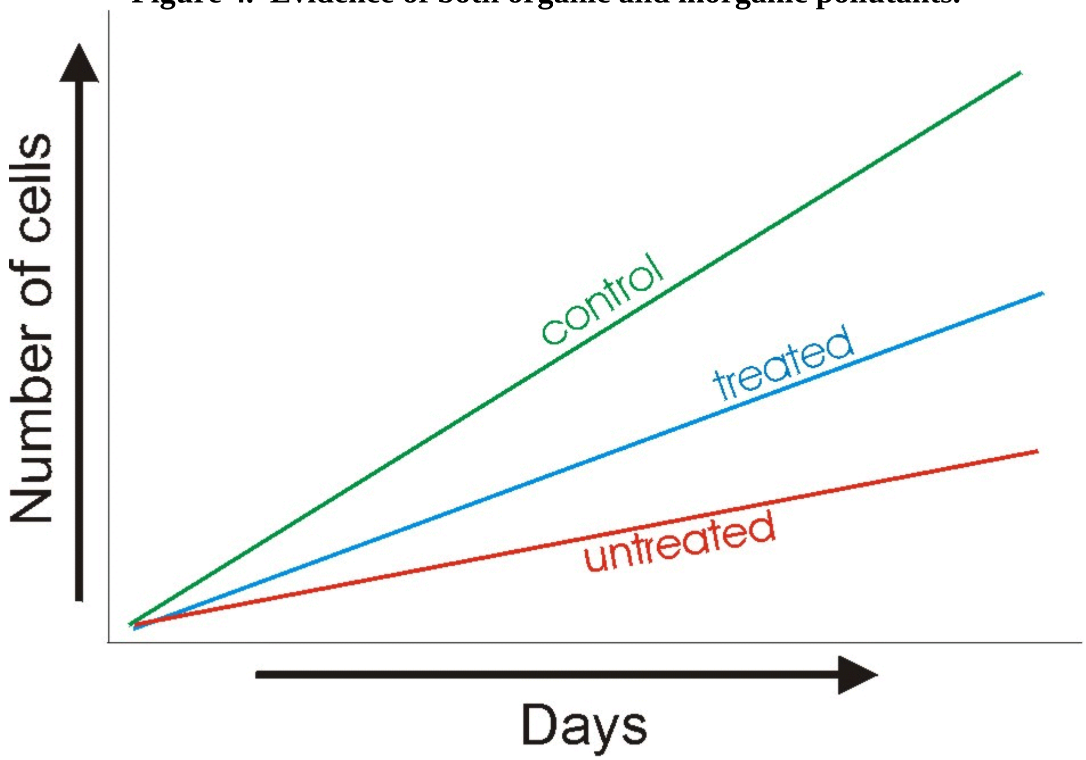
Figure 3. Evidence of an inorganic pollutant.



D. Evidence of both organic and inorganic pollutants.

Conceivably, both organic and inorganic pollutants could be present. In such a situation, we might expect that treatment of the water with activated carbon would remove only some of the pollutants, and therefore only partially reduce the inhibition of *Pseudokirchneriella* growth, as shown in Figure 4. There are other possible explanations for this type of result, making it risky to conclude absolutely that both types of pollutants were present. For example, if two organic pollutants with different affinities for activated carbon were present, only one may be effectively removed by the water treatment.

Figure 4. Evidence of both organic and inorganic pollutants.



E. Evidence of an eutophying pollutant.

Another possible result may indicate the presence of an eutrophying pollutant. Eutrophying pollutants frequently originate as runoff of agricultural fertilizers, which are typically inorganic forms of nitrogen. Therefore, as expected these types of pollutants do not bind to activated carbon. However, eutrophying pollutants are inorganic nutrients for algae, and their presence can be detected by an enhancement (rather than inhibition) of the growth of *Pseudokirchneriella*, as shown in Figure 5. Notice in this case the calculated value will be negative (e.g., -0.39) which reflects a stimulatory effect of the water on the growth of the algae. In this situation, report your results as the absolute value, expressed as "% Enhancement" (e.g., 0.39%).

Figure 5. Evidence of an eutrophying pollutant.