Can Lake Water Be made Safe?

Teacher Notes

In an activity such as this it is very important to distinguish between chlorine the element and chlorides, compounds involving the chloride ion. Chlorine, the element, can be obtained on a large scale from oxidation of sodium chloride (the chloride ion)

$$2Cl^- - 2e^- \rightarrow Cl_2$$

Chlorine, as the element, is reasonably soluble in water and also reacts chemically. The chemical reaction is

$$Cl_2 + H_2O \rightarrow OCl^- + Cl^- + 2H^+$$

Thus chlorine water is acidic. It is also an oxidizing agent as the OCl^- is readily reduced .

$$OCl^- + 2H^+ + e^- \rightarrow Cl^- + H_2O$$

The acidity can be reduced in the presence of OH^- ions. This is the case if bleach (sodium chlorate(I)) is used instead of chlorine water. Sodium chlorate (I) (NaOCl) is the salt of a weak acid and a strong base. It is hydrolysed in aqueous solution where H+ and OCl^- tend to form the more covalent HOCl thus raising the pH.

Activity 1

In the laboratory, the most convenient way to make chlorine in solution (the most useful form for school experiments) is to electrolyse a solution of sodium chloride by simply dipping both electrodes into the solution and passing a low voltage (6 volts) through it. There is no need to collect the gas from the anode (nor the cathode although the hydrogen gas evolved at the cathode can be collected for subsequent testing if desired.
Suitable equipment for students to use for undertaking this experiment is a microkit so as to minimize the smell of chlorine (this should not really be a matter of concern unless produced in large quantities, as students will be familiar with the smell from swimming pools and whenever bleach is used at home)..

The solution formed is actual a dilute bleach solution and contains Na^+ as well as Cl^- ions. It is similar to chlorine water (but less acidic).

Developer: Felix Atachu and Sahondra Rasuloarijao. Edited by Jack Holbrook

Institution: International Council of Associations for Science Education (ICASE)
Country: South Africa

Activity 2

Testing the lake water

- collect samples of water from the lake.
- in one sample, the control, don't add the chlorine water or sodium hypochlorite (bleach)
- in the other add different concentrations of chlorine water and/or sodium hypochlorite (bleach).
- test for the presence of living microorganisms in all water samples, both at the initial stage when the chemicals are first added and then later at the end of the lesson..
- records the results in a suitably constructed table (students decide how to construct the table for themselves).

Microorganisms

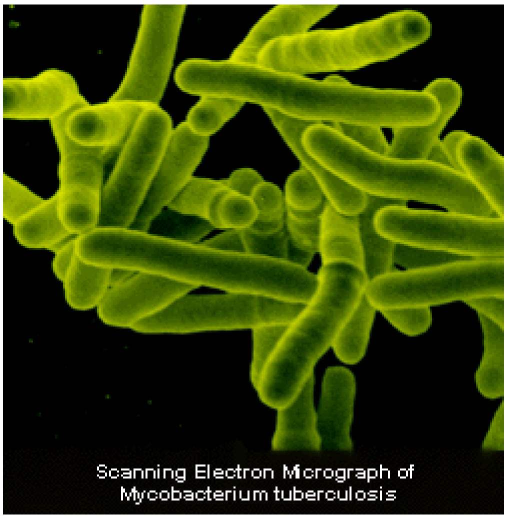
Microorganisms or *microbes* are organisms which are microscopic (too small to be seen by the human eye). The study of microorganisms is called microbiology. Microorganisms can be bacteria, fungi, archaea or protists, but not really viruses and prions, as these are generally classified as non-living (they can be called microbes). Micro-organisms are generally single-celled, or as usually recorded - unicellular, organisms; however, there are exceptions as some unicellular protists are visible to the average human, and some multicellular species are microscopic.

Microorganisms live almost everywhere on earth where there is liquid water, including hot springs on the ocean floor and deep inside rocks within the earth's crust. Microorganisms are critical to nutrient recycling in ecosystems as they act as decomposers. As some microorganisms can also fix nitrogen, they form an important part of the nitrogen cycle. However, and sadly, pathogenic microbes can invade other organisms and this causes diseases which kill millions of people every year.

Developer: Felix Atachu and Sahondra Rasuloarijao. Edited by Jack Holbrook

Institution: International Council of Associations for Science Education (ICASE)
Country: South Africa

Bacteria versus Viruses



Scanning Electron Micrograph of Mycobacterium tuberculosis

Bacteria:

Most bacteria are very good. Only a few cause disease. Antibiotics can kill the bacteria.

However, due to misuse and overuse of antibiotics, bacteria today are more resistant to these drugs and are harder to kill. Tuberculosis (TB), for example, now affects 1/3 of the world population.

What's the difference between bacteria and viruses?

Bacteria are one-celled living organisms. The average bacterium is 1,000 nanometers long (one nanometer is one billionth of a meter). All bacteria are surrounded by a cell wall. They can reproduce independently, and inhabit virtually every environment on earth, including soil, water, hot springs, ice packs, and the bodies of plants and animals.

Viruses are tiny geometric structures that can only reproduce inside a living cell. They range in size from 20 to 250 nanometers (If a bacterium were human size, a typical virus particle would look like a tiny mouse-robot. If an average virus were human size, a bacterium would be the size of a dinosaur over ten stories tall). Outside of a living cell, a virus is dormant, but once inside, it takes over the resources of the host cell and begins the production of more virus particles. Viruses are more similar to mechanized bits of information, or robots, than to animal life. Hence the question – are viruses living?

What's the difference between a viral infection and a bacterial infection? Are they both contagious?

Simply put, viruses cause viral infections, and bacteria cause bacterial infections. But they're also different in other ways.

Unlike bacteria, viruses are not "living" organisms. So they require living hosts — such as people, plants or animals — to multiply. When a virus enters your body, it invades some of your cells and takes over the cell machinery, redirecting host cells from their normal function to produce the virus. Viruses may eventually kill their host cells or become part of these cells' genetic material. Some viruses are spread directly from person to person (contagious), such as influenza and the common cold. Other viruses, such as yellow fever, are not.

Bacteria are single-celled microorganisms that reproduce by dividing. Most bacteria can grow on nonliving surfaces. Not all bacteria are harmful, and some are even beneficial. But when infectious bacteria enter your body, they make toxins that can damage specific cells they've invaded. Some bacterial infections are contagious, such as strep throat and tuberculosis. Others — such as bacterial infection of the heart valves (endocarditis) or bone (osteomyelitis) — are not.

The distinction between viruses and bacteria is important. This is because drugs that are effective against one type of infection won't work against the other type.

Bacterial infections are treated with antibacterial antibiotics. Taking these antibiotics when you have a viral — and not a bacterial — infection won't treat the viral infection and may even be harmful. In addition, antibacterial antibiotics may have serious side effects. Antiviral antibiotics are available for some types of viral infections, such as influenza and herpes.

Some Facts about Bacteria

Bacteria help our bodies with digestion and produce needed vitamins. Bacteria also help us by destroying harmful organisms within our bodies.

There are more bacterial cells in your body than there are human cells.

Most bacteria reproduce using a process called "binary fission." To do this, a single bacterium will grow to twice its normal size and then split into two "daughter" cells. The two new cells are exact copies of the original bacterium.

Bacteria are used to make cheese, milk, sourdough bread and yogurt.

99% of all bacteria are helpful.

Dead or weakened bacteria and viruses are used for making helpful vaccines.

Scientists estimate that bacteria produce nearly half the oxygen found in the atmosphere.

Helpful bacteria are used to purify water at sewage treatment plants and to break down oil after oil spills.

One healthy bacterium, given the proper environment, could reproduce into a colony of more than 2 million in just seven hours.

There are more microbes on your body than there are humans on the entire planet.

An area of skin as small as 6.5 square cm (1 square inch) may be home to more than half a million microbes.

Some different kinds of bacteria.

Pneumonia = coccus	Whooping Cough (pertussis)	Diphtheria	Staphylococcal Infections	Coliform Bacteria: E. Coli
Streptococcal Infections	Scarlet fever, rheumatic fever	Tetanus	Tuberculosis = bacillus	

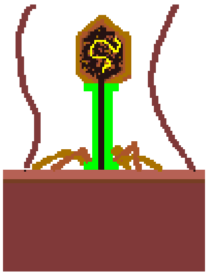
Developer: Felix Atachu and Sahondra Rasuloarijao. Edited by Jack Holbrook

Institution: International Council of Associations for Science Education (ICASE)
Country: South Africa

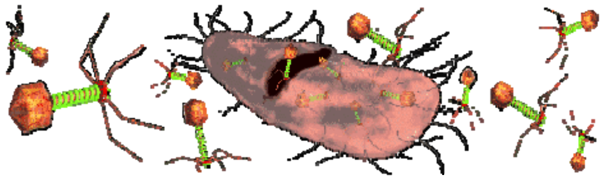
Viral Diseases

Viruses are parasites. They are made up of DNA or RNA surrounded by a protein coat. They take over cells so that they can reproduce themselves. The cells usually die after reproduction. RNA viruses are not stable and therefore, they mutate often. DNA viruses are more stable and therefore, they mutate less often.

The T-4 Bacteriophage virus is about to attack the bacterium.



The virus injects its genetic material into the bacterium.



The bacterium explodes after it is forced to make copies of the virus!

Some different viruses.

Smallpox	Poliomyelitis	Hepatitis	Ebola Virus	Hanta Virus
Measles	Rabies	Chicken pox	Common Cold	Influenza
HIV	Mumps			

Antibacterial Soaps

Do antibacterial soaps work better than regular soaps?

The scientific studies comparing antibacterial soap to regular soap give apparently contradictory results. Some studies show it is better, others that it is worse, and others seem to show no difference. Taken together, these studies indicate that antibacterial soaps are more effective at reducing infections by some organisms (especially staph and strep); they are worse at preventing some types of infections (especially by some of the organisms called gram negative bacteria, since the antibacterial soaps kill much of the beneficial bacteria that normally live on our skin and protect us from some of these gram negative organisms); and they make no difference for some types of infections (such as cytomegalovirus [CMV], or Clostridia -- the bacteria that cause gangrene).

Chlorine Disinfectants

Chlorine disinfectants, effective against a wide array of disease-causing microorganisms, yet inexpensive, play a major role in preventing foodborne illness. The U.S. Environmental Protection Agency (EPA) has approved the

Developer: Felix Atachu and Sahondra Rasuloarijao. Edited by Jack Holbrook

Institution: International Council of Associations for Science Education (ICASE)
Country: South Africa

use of chlorine disinfectants in the food industry where they are used for everything from disinfecting irrigation water and sanitizing fruit and vegetable washes, to disinfecting food-processing machinery, food-contact work surfaces and food transport containers. Although the U.S. food supply is among the safest in the world, foodborne illness affects millions of Americans annually, resulting in thousands of deaths-an indication that there is yet more work to be done with the versatile public health allies known as chlorine disinfectants.

Chlorine Disinfectants Remain Relevant as the World Changes

Consumers today can choose from a wide variety of fresh fruits and vegetables in any season, thanks to increased importation of produce from other lands. But this great convenience is not without risk. Food safety standards in other countries vary, and shipping distances have increased, raising the potential for foodborne pathogens to gain a stronghold in transit. Chlorine disinfectants applied to food transport containers can help minimize this risk.

Two trends, the aging of the Baby Boomers and the increasing use of daycare services by working families, point to the important role of chlorine in keeping elderly and child care facilities sanitized with the use of efficacious, inexpensive chlorine disinfectants.

Finally, increasing numbers of people are frequenting restaurants-subjecting themselves to the food-handling and preparation procedures followed by these establishments. Restaurants can become prime breeding grounds for foodborne illness. Chlorine disinfectants can be used to keep germs in check in restaurant food preparation and eating areas.

The microbial world is not static. Microorganisms morph continually in an effort to remain viable. Antibacterial products and overuse and misuse of antibiotics have induced rapid change in bacteria, making some germs resistant to existing drugs, but fortunately, not to chlorine disinfectants. Chlorine disinfectants penetrate the slime coatings, cell walls and resistant shells of microorganisms, destroying bacteria, viruses and parasites.

Because it is so effective against germs, chlorine bleach is registered by the EPA as a hospital disinfectant. With hospital infections on the rise, proper hygienic practices are critical to prevent the spread of infections, including those caused by certain antibiotic-resistant bacteria. Fortunately, chlorine bleach can be used to destroy these and other microbes where they may live for hours on frequently touched surfaces, "waiting" to be picked up by their next host organism.

Chlorine disinfectants have long been associated with public health. For over a century they have been used to destroy waterborne pathogens in developed countries, providing safe municipal drinking water and virtually eliminating serious waterborne illnesses, such as cholera, typhoid and hepatitis A. In 1997, Life magazine called drinking water chlorination and filtration "…probably the most significant public health advancement of the millennium."

Developer: Felix Atachu and Sahondra Rasuloarijao. Edited by Jack Holbrook

Institution: International Council of Associations for Science Education (ICASE)
Country: South Africa

Ultraviolet Water Sterilizers

Ultraviolet was first used to destroy bacteria in the early 1920's. Today, ultraviolet germicidal energy for purification of water is unmatched by any other purification method for efficiency, simplicity and dependability. Ultraviolet technology is preferable over the other three methods (chlorine, iodine and distillation). UV works almost instantly, leaving no residuals or chemicals in the water.

Ultraviolet energy is produced by low pressure mercury lamps. The lamps are made of special glass, which allow the passage of light waves emanating at a specific wavelength (254 nanometers). This particular wavelength has the ability to kill all microorganisms with which it comes in contact. The destruction is accomplished quickly and effectively. The UV rays strike the various microorganisms whether they are bacteria, virus, yeast, mold, algae, and break through the outer membrane. The radiation from the lamps reaches the heart of the organisms (commonly known as the DNA) where it causes abrupt modifications. The modified DNA transmits incorrect codes or messages, and this impairment actually brings about destruction of the microorganisms.

Ultraviolet energy is not a chemical treatment. It's deadly to microorganisms, but does not pose a threat to people, equipment or any indoor environment.

Ultraviolet light disinfection also has its disadvantages. This disinfection technique is more effective against bacteria than against viruses and parasites such as *Giardia*. There is no simple test to determine whether or not the system is providing proper disinfection. Ultraviolet light devices are most effective when the water is clear and allows the light to easily pass through. Therefore, ultraviolet light devices are often combined with other treatment devices such as mechanical filters, activated carbon filters, water softeners, and reverse osmosis systems to provide complete water quality solutions. Safety features, such as detectors that activate audio and visual lamp alarms in case of lamp failure, are available to ensure that adequate disinfection conditions are maintained.

Ozonation is another method of water sterilisation. This process uses ozone (O_3), which is a more powerful disinfectant than chlorine. Ozone produces no tastes or odours in the water. However, as a gas, ozone is unstable; it has a very short life. It must therefore be generated at the point of use.

A final point

The majority of the world's infectious diseases emerge, not in the teeming tropics of the Southern Hemisphere, as one might imagine, but in the industrialized North, according to Peter Daszak of the Consortium for Conservation Medicine at Wildlife Trust in New York City. In spite of the fact that high-profile diseases such as AIDS, SARS and Ebola originated in the Southern Hemisphere, Daszak's global map shows that, between 1940 and 2004, most infectious diseases emerged in technology-rich Europe, North America and Japan. According to a recent article in Science, foodborne infections, drug-resistant bacteria and international travel are three major public health threats contributing to infectious disease outbreak in the highly developed nations of the Northern Hemisphere.

Developer: Felix Atachu and Sahondra Rasuloarijao. Edited by Jack Holbrook

Institution: International Council of Associations for Science Education (ICASE)
Country: South Africa