Literacy Task: Bacteria Investigation
Biology I (9th-12th Grade)

Writing Prompt (Must incorporate and be relevant to the business/industry in which you worked and must require students to read two texts to complete).

You will read two texts and using the information obtained in the texts you will write a letter for the employer to give to employees that will inform them of the potential dangers of bacteria in the coolant. Be sure to include ALL of the following:

a. Potential dangers for the employee, the product being made, and the equipment and what the employee should be doing to protect themselves and the product.
b. Potential cost associated with bacteria in coolant and how the employees can help the factory to control costs.
c. The differences between anaerobic and aerobic bacteria and how each should be treated in this factory setting.

Common Core State Standards

List the Common Core State Standards associated with your task.

CCSS.ELA-Literacy.RST.9-10.2
Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text
CCSS.ELA-Literacy.RST.9-10.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9-10 texts and topics*.

Essential Understandings

What key insights should students take from participating in this task?

Student should understand that:

- Bacteria is present everywhere.
- Bacteria can range from dangerous to harmless.
- Harmless bacteria can turn dangerous in certain situations.
- Anaerobic bacteria is present only if oxygen is not present.
- Aerobic bacteria is present only when oxygen is present.
- Anaerobic bacteria usually feeds on and takes over from aerobic bacteria.
- Bacteria can be introduced to relatively closed systems through simple contamination.

Text Dependent Questions

At least 5 open-ended text dependent questions.

1. Describe the difference between anaerobic and aerobic bacteria.
2. What are microbes and what equipment would you use to view them?
3. Describe the environment that bacteria live in and the environment that fungi live in.
4. *You have been asked to investigate a strange smell that occurs in a factory each morning when the machines are turned on. How might you use what you have read about to determine what is causing the smell?*
5. *Based upon the above observation, if you have determined this to be bacteria, how you would design a test to further analyze the bacterium?*

Texts

Links to two texts used. Include a brief synopsis (2-3 sentences describing the texts).

Text 1:
http://www.carbideprocessors.com/pages/machine-coolant/why-coolant-becomes-unusable.html
This article describes how bacteria can get into machine coolant, how it is harmful to the process of manufacturing and how it can be prevented.
This article is not going to be used in full, so I added the intended portions to this template.

Text 2:
http://www.koolrite.com/bacteriacontrol.html
This text describes how microbes are detected in coolant and what an acceptable number would be. It also includes the Do's and Don'ts of cleaning coolant.
This article is a small part of a larger website that could be used as an interactive activity.

Additional article:
http://www.mmsonline.com/articles/ozone-provides-solution-to-bacteria-in-coolants
This article describes how ozone can be used as a solution to bacteria in coolants. It goes deep into the potential harmful effects on the machines, the parts and the human workers who run the machines.

I would use this article as a finishing touch after the students have completed their task to show them that there is currently research being done on this topic and progress is being made in the search for a solution.

Text 1:

Why Coolant Becomes Unusable

Dirty machine coolant is expensive and dangerous

10% annual loss of machine value

Dirty machine coolant is most expensive for the damage it does to machines. Dirty machine coolant can cause a loss of as much as 10% of the cost of the grinder. With a $50,000 grinder this is $5,000 a year. Refer back to the Machine Coolant Index for ways to keep Machine Coolant Clean.

Dirty machine coolant eats rubber, plastic, Plexiglas, insulation and human flesh.

Machine coolant never really wears out. Machine coolants and cutting oils become unusable when they become excessively contaminated with bacteria, tramp oil, metal fines, or wastes. They can break down from use but, if water based, are most commonly broken down by bacteria growing in the system.

When a system develops a drastic change in pH, detergency, lubricity, or odor, a bacteria check should be made.

Bacteria find their way into fluids through a variety of ways. For instance, there are bacteria in the water used for diluting and mixing. Bacteria from an operator's hands, sweat, and saliva also get into machine coolants. Bacteria thrive on wet parts and lurk in the air.

Surprisingly, there are people who find it easy to confuse machine coolant sumps and holding tanks with toilets or food disposal units. Poor housekeeping practices add huge numbers of microorganisms to the system. Bacteria also live in the sludge that settles in machine sumps and machine coolant flumes. In short, bacteria are everywhere.

Bacteria & Fungi

Bacteria chemically alter machine coolants, destroying lubricants and corrosion inhibitors, while releasing corrosive acids and salts into the fluid. Microbial action directly affects the machine coolant resulting in the splitting of emulsions, decreased pH, increased corrosion, degradation of the ingredients in the machine coolant and a loss of lubricating ability within the machine coolant. Odors may develop including hydrogen sulfide as a product of the bacteria's metabolism. Bacteria may expose workers to pathogens and contribute to respiratory irritation and skin irritation, like dermatitis. Work piece quality decreases, resulting in increased surface blemishes, decreased tool life, and increased time to treat for bacteria and repair equipment. The bacteria may also cause increased foaming and separation in the system and cause clogged lines, filters, and valves.

The presence of wastes, tramp oils and metal fines can stimulate the growth of bacteria. The life span of most water based machine coolants can be extended two or twelve fold with proper management techniques.

Bacteria and other microbial organisms thrive in the environment created by the impurities in the machine coolant. Tramp oil, lubricants, hydraulic oils leaked by machinery, minerals in the water, mineral oils, fatty acids, emulsifiers, corrosion inhibitors, other additives, discarded food and waxes are food for microorganisms.

Microbial contamination is a major cause of fluid spoilage. All water-miscible fluids are susceptible to microbial deterioration that can significantly reduce fluid life. Bacteria prefer water-miscible fluids, because they need water to grow. Without moisture, most bacteria cannot reproduce and multiply once introduced to a new environment.

Bacteria populations can double as frequently as every 30 minutes. The greater the bacterial growth rate in a fluid, the faster the fluid becomes rancid. As bacteria multiply, they produce acids, which lower the pH of the fluid, causing increased corrosion and reduced lubricity. Bacteria may also darken the fluid significantly, resulting in stained parts.

Aerobic

Most bacteria, which cause fluid to become rancid, are aerobic. Aerobic bacteria need oxygen for metabolism. In the typical machine coolant system, there is no shortage of oxygen. As machine coolants cycle through, they come into contact with air at the surface of sumps and holding tanks. Fluids pick up oxygen as they are ejected from the nozzle and just about anywhere else machine coolant is exposed to the air.

In the absence of oxygen, they will continue to survive, but grow very slowly until oxygen is reintroduced. Once they can "breathe" again, facultative bacteria will resume reproduction. Aerobic bacteria reproduce by dividing in two approximately every 20 to 30 minutes. A single well-fed bacterium can produce billions of others in less than half a day.

Anaerobic

Anaerobic bacteria grow in oxygen-poor environments. They grow in systems that are inactive for long periods of time. Inactivity allows tramp oil to rise to the top of the sump, creating an effective barrier between the metalworking fluid and atmospheric oxygen. Consequently, the amount of oxygen present in the fluid decreases, aerobic bacteria die, and anaerobic bacteria begin to flourish. They feed upon the machine coolant and produce hydrogen sulfide, which produces the rotten-egg odor, which causes Monday morning odor.

This type of bacteria grows much more slowly than the aerobic, dividing in two approximately every four hours. Anaerobic bacteria will usually not grow until aerobic bacteria have first attacked the fluid and the oxygen is depleted. Some components of machine coolant-emulsifier systems are naturally toxic to anaerobic bacteria; that's why adding fresh machine coolant makeup to stinky machine coolant will "freshen up" the mix but only for a short time.

Fungi

Besides bacterial growth, there is another whole group of microorganisms that can infect machine coolants. Collectively, they are referred to as fungus, which, in reality, is a combination of molds and yeasts.

Fungi degrade metalworking fluids by depleting rust inhibitors. Fungi also cause musty or mildew-like odors and form slimy, rubber-like masses on machine system components that may eventually plug fluid lines.

While bacteria are essentially animal-like and grow rapidly as discrete cells or particles within the fluid, fungi are plant like, growing in layers on surfaces (e.g., inside pipes). Bacteria and fungus compete for the same food sources, and because of bacteria's animal-like nature, they can generally out compete fungus. As a consequence, if a machine coolant system has a moderate, stable (neither rapidly increasing nor decreasing) bacterial population, the bacteria will generally control fungal growth.

Conversely, if a machine coolant system has a consistently low bacterial population and the fluid will allow fungal growth (soluble oils tend to support bacterial growth and chemical [synthetic] fluids tend to support fungal growth), the fluid will likely develop a significant fungal population eventually.

Fungus can be even more of a problem than bacteria because fungal accumulations can interfere with machine functioning and can plug machine coolant filters and piping. While there are a number of effective microbiocides that can be added to machine coolants to control bacteria, there are very few effective fungicides for use in machine coolants.

Bacteria Control

The more rapidly bacteria grow, the faster they alter the fluid. That makes controlling the rate of bacterial growth extremely important. If the rate of growth is limited, the harmful effects are reduced. Biological growth is controlled through a combination of practices. These include water quality control, proper maintenance of fluid concentration and pH, routine equipment maintenance, biocide treatment and aeration.

Housekeeping

The best way to effectively control bacterial growth is good housekeeping.

The best method for controlling biological growth is through routine cleaning of machines, machine coolant lines, and sumps/reservoirs. Machines, exhaust blowers, and hydraulic seals should also be maintained to prevent oil leaks from contaminating the fluid.

Train your employees to keep trash, solvents, tramp oil and other foreign material out of the machine coolant system.

It does little good to put fresh machine coolant into a dirty machine if you're only going to suck out the old before putting in the new. This practice provides fresh food for the bacteria that are in the swarf and sludge that remain in the machine sump, on machine surfaces, and in the machine coolant circulating systems.

Use good water

The minerals present in most water can destroy desirable machine coolant properties and form deposits. In addition, Fungi feed on dissolved minerals in water. Controlling the mineral content of the water used for metalworking fluids can control fungi growth. Consider using deionized water when mixing machine coolant formulations.

Fluid selection

One of the most important methods of keeping bacterial growth in check is to be sure that the cutting fluid manufacturer you select uses high purity materials for its products. Bacteria have very specific appetites and some materials are much better food for them than others.

Fluid manufacturers that understand the biology of microorganisms select raw materials that bacteria do not find appetizing. Machine coolants formulated with materials bacteria find undesirable are less vulnerable to bacterial attack.

Clean machine coolant in process

Screen out and recycle metal fines. Remove tramp oils and metal chips.

Accumulations of chips and fines in a sump promote bacterial and fungal growth. These particulates increase the surface area available for microbial attachment, and biocides cannot effectively reach the fluid trapped in these chips and fines. Particulates in the bottom of a sump become septic or rancid if not periodically removed.

Even if the majority of the fluid is free of bacteria, the sludge in the bottom will continue to harbor bacteria and create a septic condition. This can dissolve metals, possibly increasing the toxicity of the fluid to a level at which disposal through a local wastewater treatment plant is no longer permitted. Laboratory analysis will reveal whether the toxicity of the fluid makes it a hazardous waste.

Some bacteria prefer oil as a food source, so they tend to grow rapidly in those machines that leak substantial amounts of lubricating and hydraulic oils. Consequently, everything should be done to reduce tramp oil contamination. Contaminant oils and greases that do make it into machine coolant should be skimmed off the surface or centrifuged out of the fluid.

Monitor your sumps

Monitor machine coolant quality. Know when you must add make up or additives. Know when bacterial growth is about to get out of hand. One way to do this is by keeping records of when and how much additives or make up machine coolant are added. Signs of bacterial growth should also be recorded.

Many machine coolant concentrates contain biocides and pH buffers. Therefore, preventing fluid from becoming overly diluted helps control microorganisms.

Ideally, the pH for water miscible metalworking fluids should be kept in the limited range of 8.6 to 9.0. This slightly alkaline range optimizes the cleaning ability of the fluid while preventing corrosion, minimizes the potential for dermatitis and controls biological growth. If the pH drops below 8.5, the fluid loses efficiency, can attack ferrous metals (rusting), and biological activity will significantly increase. A pH greater than 9.0 may cause dermatitis and corrosion of nonferrous metals.

Regular monitoring of a fluid's pH is a simple means of anticipating problems. Fluid pH should be measured and recorded daily after the machine is placed in operation. Steady pH readings give an indication of consistent fluid quality. Swings in pH outside the acceptable range indicate a need for machine cleaning, concentration adjustment or the addition of biocide. Each action taken to adjust the pH to the desired operating range should be documented in the machine logbook and evaluated for effectiveness. Any rapid change in pH should be investigated and action should be taken to prevent damage to the fluid.

Although fluid pH usually remains constant because of buffers contained in the concentrate, it can change after initial mixing due to water evaporation. Improper control of microbial growth will also alter fluid pH. Byproducts of microorganisms produce offensive odors and lower fluid pH. As the fluid becomes rancid or septic, it becomes more acidic. Sudden downshifts in pH usually indicate increased biological activity or a sudden change in concentration due to contamination. If machine coolant concentration and pH both jump downward, the sump has been contaminated. If machine coolant concentration remains fairly constant while pH decreases, biological activity has probably increased significantly.

Weekly or biweekly monitoring is typically recommended for detection of microbial contamination, especially during the early stages of developing a fluid management program. With experience, machine shops may determine that a less frequent monitoring schedule is suitable for their operation.

Clean sumps

Sanitize sumps and machinery on a regular basis. Remove all old machine coolant and sludges. Flush out comers. It's no use putting good machine coolant into bacteria laden equipment. If necessary, retrofit sumps to make cleaning easier by lining with sheet metal or epoxy and creating rounded corners.

If a machine is thoroughly cleaned with a proper cleaner, thoroughly rinsed, and then filled with clean, fresh fluid, the fluid will last four to six times longer than it would in a machine that is simply "sucked out" and recharged with fresh machine coolant.

Text 2:

Taking control of bacteria and fungus

Microbes

Microscopic organisms (microbes) such as bacteria and fungus are present in our bodies, our skin, the air we breathe and the water we drink. The vast majority of these microbes are not pathogens (disease causing) and therefore do not cause problems in metalworking coolants. However, some microbes are ideally suited for life in the warm, damp, dark environment of a coolant sump.

Bacteria are actually microscopic, one-celled animals. Fungus, mold and yeasts make up the plant microbes. Each has its own characteristic and favorite conditions for growth. Of the two, bacteria are relatively easy to control.

Once inside a system, fungus, yeast and mold can be very difficult to treat. Since bacteria and fungus compete for the same food sources, a healthy population of bacteria keeps the growth of fungus under control.

Why Worry?

The uncontrolled growth of microbes can lead to problems such as odors, plug lines, corrosion and coolant emulsion instability. A clean, uncontaminated sump can control the growth of microbes.

How to Measure Microbes

Microbes are measured by the number of colonies per milliliter. Bacteria counts of 10^2 to 10^4 are considered desirable in machine coolant systems. Unfortunately, there is no absolute amount that constitutes high bacteria counts. In some cases, you may have to treat at 10^4 if you are experiencing problems. Some sumps may not need treatment at 10^8, however.

Dip paddles are widely accepted as the main method of measuring microbes. For many years paddles covered with growth media have been dipped into coolants and allowed to develop for 24 to 48 hours. One side of the paddle will produce stained colonies of bacteria, while the other side produces stained colonies of fungus. By comparing the density of the colonies to standard samples you can estimate the actual counts of 10^2 to 10^8.

The HMB meter is another widely used tool for measuring microbes in large systems. This is a 15-minute test that produces a count of microbes in the system. The ability to monitor microbes without waiting several days for growth counts can be a very valuable option for your business.

Treating for High Microbe Counts

The use of bactericides to lower the bacteria and treat fungus, yeast and mold are the most common methods of control. Many different products are sold for this purpose alone. Follow the advice of the coolant manufacturer before incorporating bactericides into your coolant.

In any case, bactericides and fungicides should be tightly controlled. As always, follow the manufacturer's guidelines on the package before treating your sump.

Bacteria are generally dispersed throughout the coolant and typically respond well to bactericides. If you have chips packed into the bottom of the sump, bactericides may not get to the source of the infection. In this case, chemical cleaning might be a better option.

When treating for heavy fungus, you may have to chemically clean and scrub the surfaces to eradicate the infestation. Funguses grow in tight colonies and the fungicide alone cannot penetrate their mass.

Pasteurization, O_2 injections and extreme filtration will also reduce microbe counts. However, without balancing the biocides, microbes tend to rebound very quickly.

New Issues

It is important to keep up with the changing information about coolants and controlling microbes. These issues should be investigated with your safety department and coolant supplier.

Bactericides that produce formaldehyde releases have raised some concern. As a result, the auto industry has begun to discontinue the use of such bactericides.

New information about Mycobacterium, a difficult to identify strain of bacteria, has prompted concern about controlling counts at lower levels (even though no problems may exist).

Do's and Don'ts

Don't use bleach to disinfect coolant.
Don't let untrained people make additive additions to coolants.
Do follow the recommendations of your coolant supplier for all issues.