TEACHER REFERENCE PAGES-WATER QUALITY LAB

PURPOSE
The purpose of this unit is to give students hands-on experience in testing a variety of water quality factors.

OVERVIEW
The focus of the introductory lab is to awaken students to the idea that adding heat or organic materials to water will change its oxygen content, thereby altering it as a habitat. The lab is designed to allow students to take dissolved oxygen readings directly and to encourage them to bring in their own samples to test them for coliform bacteria.

Suggestions:
1. Demonstrate the "Alka-seltzer" example on page 2.
2. In order to demonstrate the relationship of temperature and oxygen concentration, produce a graph of D.O. at various water temperatures.

3. Because of the color change some students may get the impression that the pH change in the milk in Part I is a sudden change. Using a pH meter, demonstrate that the pH actually changes over time as the milk is consumed.

4. You may want to emphasize that Part I does not demonstrate the drop in D.O. as temperature increases. It is overshadowed by the increase in yeast metabolism.

5. Most of us know that we use methylene blue as a pH indicator but apparently oxygen combines with methylene blue as well and as the oxygen is used it comes out of the indicator and the color changes. It has also been suggested the methylene blue be replaced with bromthymol blue which also works well. Students have some difficulty with the color change. There is a light residual color that seems to remain. Watch for it and advise the students. Personally I'm going to do this part of the investigation with pH meters.

6. Tap water should be drawn the night before. This will allow time for the chlorine to leave the water. You may want to aerate the water overnight. This will saturate the water. Water directly from the tap has very little dissolved 0_2.

7. Yeast can be obtained either from the grocery store or from one of the bulk supply houses. The little packages from the grocery store have approximately 6 g. of usable yeast, some just sticks to the foil of the package.

8. One modification in the assembly of the filtration system in Part III is to leave off the air filtration assembly.

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BACKGROUND

When microorganisms, like yeast, consume organic matter in a water solution they also use oxygen in the water, just as people use oxygen to metabolize their nutrition. When water is used in homes or industry, it becomes contaminated with sewage or other organic matter. If this waste water were to be discharged into the environment, say into the ocean or a river, naturally occurring microorganisms like bacteria and yeasts would consume the pollutants, and use up most or all of the dissolved oxygen in the process. Water which is depleted in dissolved oxygen cannot support fish or most other forms of aquatic life, and many natural water bodies have been rendered biologically dead due to polluted waste water discharges. For this reason, contaminated waste water must be treated to remove the organic waste before it is put back into the environment. This is the basic idea behind the concept of waste water treatment.

Your test solution represents polluted water that is being "cleaned" by the action of a microorganism, yeast. In order to remove the pollutant (milk), the yeast consumes some of the dissolved oxygen (D.O.) from the solution. The amount of D.O. consumed depends on the pollutant concentration. The difference between the initial D.O. concentration and the D.O. minimum is a measure of the amount of D.O. needed to degrade the pollutant, and this value is referred to as the biological oxygen demand or BOD. The more organic matter in the solution, the more oxygen is demanded by microorganisms to remove it, and the greater the BOD.

Waste water Treatment - a practical application of biochemistry to environmental quality and public health

Although few people actively seek the opportunity to visit their local waste water treatment plant, the treatment of domestic and industrial waste water is an important aspect of our national commitment to a high quality environment. Before implementation of "Clean Water" legislation and the allocation of federal matching funds to help cities and towns build treatment facilities, the unregulated dumping of raw sewage was the most serious nationwide environmental problem facing the U.S. An extreme example was the biological "death" of Lake Erie in the 1960's, when pollution rendered this Great Lake unable to support normal lake life.

Lack of waste water treatment results not only in the "look and smell" of a polluted water body, but also in the spread of waterborne disease, closing of water bodies to swimming and fishing, and the degradation and death of many aquatic organisms and ecosystems. It is still a problem in some coastal areas of the U.S., often rendering seafood unfit for human consumption. This is especially a problem for shellfish since these organisms tend to concentrate bacteria in their bodies. As shellfish are lost from an area so is a valuable recreational resource, and the price of these seafood species from non-polluted areas goes up. Waste water pollution into coastal areas has forced municipalities to close beaches in Southern California many times to safeguard the public from exposure to viral and bacterial diseases, such as hepatitis and cholera. Knowledge of waste water treatment is important, regardless whether the primary concern is for aquatic organisms, recreation, or economic reasons, because taxpayers must pay for treatment plant costs that amount to billions of dollars a year nationally.

The goal of waste water treatment is to remove the materials that are potentially harmful to the environment or human health; this is done in steps, each resulting in increasingly higher quality water and higher treatment cost. The purpose of these steps is to produce cleaned water (effluent) that can be safely returned to the environment, usually a river, large lake, or the ocean.

<u>Primary treatment</u> means removal of solids from the waste water: wood, paper and plastic are removed by a series of screens and settling basins. These materials are usually disposed of in a landfill.

Before the current environmental quality standards, primary treated water was simply chlorinated to kill microorganisms, then discharged into the environment. Now it is treated further.

In <u>Secondary treatment</u> the bacteria are use to eat or degrade organic pollutants dissolved in the water. Waste water enters an aeration tank where it is mixed continuously with high pressure air and a bacteria chosen and bred especially for degradation (consumption) of that type of waste (e.g., domestic sewage, food-processing waste, textile or paper industry waste, etc.). Under these conditions, the bacteria have unlimited oxygen and a huge amount of food (the waste) which they turn into new bacterial bodies. After several hours or days, depending on treatment plant design, the dissolved organic waste is biologically removed. The dissolved organic waste, or (measured as?) BOD (biochemical oxygen demand) is usually about 200 ppm in L.A. waste water and will be reduced to about 20 ppm when secondary treatment is complete.

Occasionally, the secondary treatment process is stopped suddenly. This usually occurs when the bacteria are killed by a toxic chemical pollutant which was added to the waste water somewhere along the sewer-collection system. This is one reason that it is illegal to dump large volumes of toxic substances, such as solvents, down the drain. In fact, the task of disposing of these substances separately requires any business or institution (like your school system, for instance) where these substances are generated to employ "hazardous waste specialists." The toxic substance not only stops the entire waste water treatment process, it can result in pollution of the large body of water into which the effluent is discharged. Unregulated dumping of hazardous substances into the municipal waste water system is illegal according to Federal and State law.

Once bacterial degradation is complete, the water is sent to a settling tank, where the bacteria settle out and the cleaned water is skimmed off. The sludge at the bottom of the settling tank is still rich in living bacteria, and is recycled within the plant to be mixed with the incoming waste water. Once the treatment capacity of the sludge is exhausted, it has to be disposed of as a type of solid waste. Most coastal cities like Los Angeles used to dispose of this waste at sea. But today this practice is illegal as this sludge contains unacceptable high levels of toxic heavy metals which causes contamination of marine organisms. Now, sludge is treated to remove its toxicity, then disposed of in a landfill or used as a soil conditioner. The most famous of the sewage sludge soil conditioners is "Milorganite"; this popular fertilizer sold nationwide is a product of the Milwaukee, Wisconsin sewage treatment system, and profits from its sale help pay the system's operating costs.

Up to this point, the treatment process has concentrated on removing solids and organic matter (BOD) from the waste water; nothing has been done to remove inorganic chemical constituents or nutrients (such as nitrate and phosphate). This requires <u>Tertiary waste water treatment</u>, a series of complicated and expensive techniques that vary with the type of waste in a particular locality. Only 5 to 10% of the waste water treatment facilities nationwide use tertiary treatment due to its high cost. It is required in areas where discharged effluent enters a water body which is sensitive to even a small increase in nutrients. Phosphate and suspended solids are induced to settle out usually by coagulation with lime (calcium oxide) or alum (an aluminum salt). Ammonia is generally removed by acidifying the waste water. Nitrate can be driven off as nitrogen gas by oxygenating, then removing the oxygen from the waste water. Some constituents, such as hydrocarbons, pesticides, and some industrial wastes, are adsorbed onto activated charcoal. Some of these chemicals can be removed by sand filtration if the chemical tends to adhere to particulate matter in the water.

Electrodialysis removes dissolved salts by forcing water through electrically charged membranes, through which water will pass but charged ions will not.
Regardless of whether the treatment process ends with secondary or tertiary methods, the water is chlorinated to kill pathogenic bacteria and viruses at the end of the treatment cycle. The "finished" water may be discharged into the environment by direct pumping into an adjacent water body (river, sea, wetlands) or used to irrigate landscaped property or commercial forest. In Los Angeles, treated waste water is used to irrigate the Griffith Park golf course, the park lands in the Sepulveda Debris Basin in the San Fernando Valley, and other green space. Tertiary treated waste water is sometimes referred to as "drinking quality" water: this water is not fit for drinking as defined under federal law, but it would not make you sick if you drank it. In fact, in the southern California area, properly treated waste water is considerably cleaner and healthier than the water found in many picturesque mountain springs, lakes and creeks; many of these water bodies contain disease-carrying microorganisms and heavy metal pollutants (think about that next time you bend to drink on a hike). It is also better quality drinking water than that served up by some large municipalities in other states.

In many instances, tertiary water discharge actually improves the quality of that body of water into which the treated waste water is discharged. Here in southern California, much of the clean effluent that is not used for irrigation is mixed with aqueduct water from the Colorado River *to improve <u>its</u> quality* and then pumped underground for storage in aquifers and eventual use as drinking water and to halt the intrusion of seawater into groundwater aquifers. Little wonder that many treatment plants in southern California are called "water reclamation plants."

It is important to remember that waste water treatment technology is still evolving and improving, both in quality of the product and in the economics of the process. In order to satisfy public demand for a cleaner, safer environment, and as a result of our Federal regulatory commitment to clean water and improved environmental quality, these increasingly complex and expensive techniques are required to treat the nation's ever increasing national load of waste water. In virtually every public opinion poll since the 1960's, Americans have demanded increased regulation and protection of the environment and public health, and have overwhelmingly stated a willingness to pay higher taxes to achieve these goals. Modern waste water treatment and the combined state and federal government role in funding and enforcement are responsible for a dramatic improvement in environmental quality and public health since the late 1950's. This successful application of science is a source of national pride and is the envy of many nations.