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|  | **The Story**  It's four o'clock in the morning, and the incessant buzz of my alarm clock imprints an eerie ringing in my tired, thoughtless mind. I roll my lifeless body out of bed and begin the ritual of preparing myself for morning swim practice. This scenario has become an everyday routine for me, and it is what drew me to the idea of the AP Biology research project. As a US swimmer I have spent a great deal of time in the water at numerous pools, exposing my body to a variety of chemical environments.  One incident in particular had the most impact in the discovery of our biology project idea. During my sophomore year at Amador Valley High School, I swam at the Amador pool everyday. For four hours a day I was exposed to what seemed to be the most stagnant water that I have ever swam in. In fact, it became so bad at one point it began to have visible effects on me. After a few months in the water, I noticed that my hair seemed dead and lifeless. After a few more months, people began to tell me that they liked the way I bleached my hair. But if my hair had been bleached at all, it was not my choice; some imbalance of chemicals in the pool must have been responsible for the change.  Two years later, I continue to swim, however I have noticed a difference. I swim at the Pleasanton Aquatic Center and my hair has returned to normal. When I heard about the AP Biology project, I spoke to my friend Alex Yang about the strange occurrences with my hair and we both agreed that this would be an interesting topic for our project. We decided that if the pool water could do this to hair, there must be some health risks involved in swimming in an unstable pool.  We decided to do basic chemical tests on a variety of public/community pools in Pleasanton and examine the results. With this data we could look for a correlation between bad water quality and health hazards. To support our data we also planned an experiment.  In this test we would attempt to culture bacteria from common pool water. We would prepare several petri dishes filled with agar and streak water samples from each pool. This would be a simple method for determining if the chemicals in the pool water worked effectively to kill bacteria. Ideally, no bacteria would grow in any of the dishes. But we expect some dishes to support bacteria growth, and hopefully, support our data as well  **The Facts**  **Chlorine** is the most common disinfectant used in swimming pools, although other chemicals such as bromine and iodine can be used as well. Chlorine serves three purposes; it kills bacteria, controls algae, and reduces organic matter by oxidation. When mixed with water, chlorine produces hydrochloric and hypochlorous acid. The latter is critical in killing germs, which it does by penetrating the walls of bacteria and attacking vital organelles. It is important that enough chlorine is added to supply a free residual of chlorine (hypochlorous acid). While some forms of chlorine combined with other chemicals can still function , free chlorine is the most effective. Chlorine should be kept at a level between 1.0 and 3.0 ppm.  Chlorine is commonly used in two forms: calcium hypochlorite and sodium hypochlorite. Calcium hypochlorite is a dry white compound sold in granular or tablet form. Added to water, it will yield 35 percent hypochlorous acid or 70 percent available chlorine. Sodium hypochlorite is liquid chlorine and it will yield about 10 to 15 percent available chlorine.  Besides maintaining chlorine at a constant level, it is common practice to occasionally superchlorinate, or "shock," a pool. Superchlorination is the introduction of two to five times the normal dosage of chlorine into pool water to counteract abnormal foreign elements. This may include excessive algae growth, hot weather, or matter brought in by an increased number of swimmers. Superchlorination will also drive off unstable forms of chlorine that cannot be restored to a useful state (chloramines). It will replace them with chlorine in its proper pH environment.   * Algae Control: There are numerous species of algae that may be problematic in keeping pools clean. Forty-six species of algae are designated as "clean water" algae, which can float in the water (planktonic) or attach to the floor and walls of the pool. Algae spore can be present in the original water source or carried into the pool through the air by wind, rain, or dust. The growth of algae is affected by temperature, pH, bacteria, and mineral or chemical content in the water. Its effects are tastes, odors, cloudy water, or increased chlorine consumption. Certain types of algae will respond to treatment better than others, and some strains have even developed a resistance to various treatments. Floating algae is generally easy to kill and can be removed by filtration. Algae that grows in crevices along the walls and floor is more difficult to kill; the pool may have to be drained and scrubbed. But growth can typically be prevented by maintaining a free chlorine residual or through superchlorination. A pool with a residual of 1.0 ppm should have no problems. Frequent checking of pH levels can also prevent algae growth. A sudden rise in pH is a sign that algae is in the water although it cannot yet be detected visually. * Bacteria and Organic Matter: These two factors are totally dependent on the number of swimmers that use the pool. The more swimmers there are, the more likely that different strains of bacteria will be brought in. An increased number of swimmers also means that organic matter can be tracked into the pool or introduced into the pool by body oils, urination, etc.   **pH** is the chemical symbol that represents the negative logarithm of hydrogen ion concentration of a given solution. It is on a scale of 1 to 14, with 7 considered neutral between acidity (1 to 6) and alkalinity (8 to 14). All living organisms are sensitive to changes in pH because it affects chemical reactions that organisms carry out. Therefore, pH is a critical factor in determining the proper conditions of a pool. Perhaps the most important effect of pH levels is on chlorine. When pH levels are too low, chlorine becomes unstable and is dissipated. This not only neutralizes chlorine function, but may also cause skin and eye irritation. When levels are too high, chlorine combines with other materials in the water, such as ammonia. In this combined state, chlorine is not available to perform its three basic functions. To see how pH effects chlorine's effectiveness, see chart. The following signs indicate an excessive amount of combined chlorine:   * A strong odor of chlorine is present. There should be no odor when pH is balanced. * Swimmers experience eye irritation. This is not a normal reaction to chlorine in its proper state. * A high test of chlorine. This is a reading of its non-functional form. * Pool water appears grayish or cloudy.   The pH of a pool should always be between 7.4 and 7.6 to insure proper chlorine function. If pH is too high, then algae growth will increase, turbidity will develop, and scaling will occur on [plaster] surfaces. If pH is too low, the effects will be electrolysis and corrosion of metals in the pool and eye irritation.  A factor also related to pH is **alkalinity**, which can cause eye and skin irritation. A pH test accounts for ionized alkalinity, but a separate test is required for un-ionized alkalinity. Alkalinity has three forms: hydroxide, carbonate, and bicarbonate. If pH is above 8.3, carbonate alkalinity may cause irritation to swimmers. Low alkalinity can be corrected without much effect on pH by adding sodium bicarbonate (or soda ash). High alkalinity will only exist in high pH, a problem commonly corrected by the addition of muriatic acid. High alkalinity is an indication of hard water, which may interfere with the ability of pool chemicals to work properly. Alkalinity should be maintained between 80 and 100 ppm.  **The Affect of pH on Chlorine's Killing Power**  (HOCL and OCl- together are free available chlorine)   |  |  |  | | --- | --- | --- | | pH | %HOCl | %OCl- | | 6.0 | 96.5 | 3.5 | | 6.5 | 90.0 | 10.0 | | 7.0 | 72.5 | 27.5 | | 7.2 | 66.0 | 34.0 | | 7.5 | 50.0 | 50.0 | | 7.8 | 32.0 | 68.0 | | 8.0 | 21.5 | 78.5 | | 8.5 | 10.0 | 90.0 |   *From Professional Pool and Spa Technicians' Guide to Chlorine* |

*This Web Site is Best viewed with 256 or more colors.*

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