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THE ANAYLSIS OF WATER CONTAMINATION AND ITS IMPACT ON SOCIETY

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by

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ABSTRACT

Many studies of water purity have been conducted in the past, but only recently have they gained widespread societal awareness. An article published in March, 2002 proved that there exists an abundance of harmful chemicals in our water supply. This paper will provide a background on water treatment techniques. We then move on to the processes such as sterilization, and the removals of taste, color and odor. We will also look at examples where the ecosystem has been affected.

In a study conducted by the United States Geological Survey in 1999-2000, several organic wastewater contaminants, better known as OWCs, were found in water samples from various waterways throughout the United States. Each of the chemicals detected are contaminants that we have only limited knowledge of their environmental and societal effects. The list of contaminants includes such chemicals as pesticides, flame-retardants, hormones, and steroids. There is reason to believe these bi-products may cause harmful effects on the ecosystem of plants and animals. Another point of concern is the fact that our wastewater treatment plants are not removing these contaminants, and they return into our water supply.

Our research begins with a look at the water treatment process as utilized in plants across the U.S. Each step of the process will be described in detail, in attempts to try to uncover ways our water purification process can be improved for generations to come. From taste, color and odor, to the health problems that may arise, these contaminants will have an impact on our lives, and something must be done.

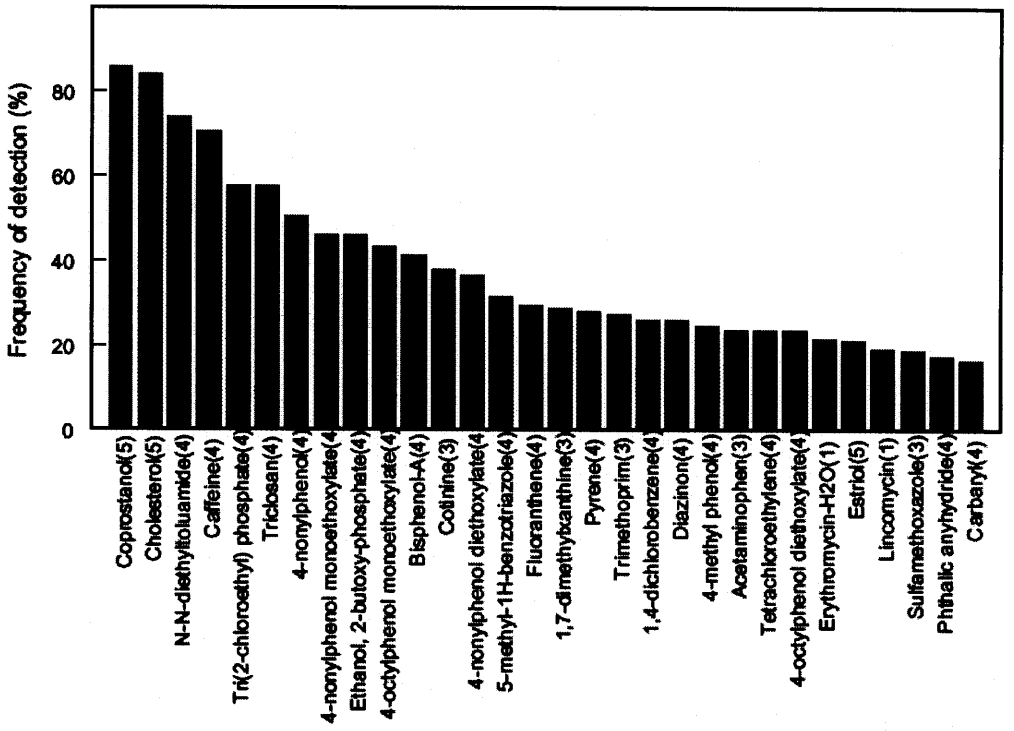
The USGS Study

Over the course of two years (1999-2000), the United States Geological Survey conducted several tests on 139 different streams and waterways scattered throughout the United States. The purpose of these tests was to detect any potentially harmful chemicals contained in the water, as well as the concentration of these chemicals. Field scientists were especially careful at each sample site, making sure not to contaminate any sample with one's own interference. For each water source, scientists sampled water from various depths in order to assure the validity of the results they would obtain.

Five tests were conducted for each sample. The first test focused on 21 antibiotic compounds, and the second test on 8 other antibiotic compounds. The third test targeted 21 prescription and non-prescription drugs, and the metabolites they create. The fourth test looked for 46 general organic wastewater contaminants, chemicals that had been detected in previous tests. The fifth test looked at 14 steroid and hormone compounds. Each test followed strict guidelines and included precise scientific procedure to reach any conclusions.

Although these tests can detect the occurrence of certain chemicals, the effects of the chemicals are virtually unknown at this point in time. "Thirty-three [of the chemicals] are known or suspected to be hormonally active; 46 are pharmaceutically active. Little is known about the potential health effects to humans or aquatic organisms exposed to the low levels of most of these chemicals or the mixtures commonly found in this study" (Buxton).

The following chart from the USGS's article shows the most frequently detected chemicals.



Our goal will be to briefly provide a background of each one of the most frequently detected contaminants, and give any evidence of unsafe traits possessed by these chemicals. In some cases there will be explanations of effects the chemical has had when tested on certain animals, as there are no specific studies that have been conducted on the effects over an entire ecosystem.

Processes of Wastewater Treatment

Wastewater treatment includes processes that remove solids. These solids include organic and inorganic compounds, both living and non-living. The living solids biomass,

are a sludge consisting of living organisms. After the water is removed from the tank, there is an abundance of leftover sludge produced from the separation. This sludge also creates a big problem for wastewater treatment, as it must also be removed somehow (Gulbrandsen).

According to Culp, the distribution of sludge destinations are: 15% put into the ocean, 35% incinerated, 25% put into landfills, and the remaining 25% used on land as fertilizers (4). This leads to a possible explanation for the abundance of organic wastewater contaminants in our water supply.

After preliminary solids removal, the water undergoes biological oxidation. This is a process in which aerobic bacteria become involved in attacking the organic compounds found in the water. These bacteria prosper in an environment with oxygen, and as they interact with the organic solids, the solids break down into carbon dioxide, water, nitrates, sulphates, and biomass.

There are two different ways to treat through biological oxidation. They are through suspended growth, or activated sludge method, or through attached growth, which uses a trickling filter.

Activated sludge is the description of the mixture of wastewater, oxygen, and biomass. This activated sludge is considered to be controlled, as each of the mixture's levels is monitored so as to have the most efficient processes. Over a period of time, while the water is aerated, microorganisms grow in the water which remove the organics. This biomass can then be removed through sedimentation.

There are several different designs for a suspended growth system. In the step feed process, wastewater enters the primary container, or aeration basin, in several

different areas distributed evenly throughout the basin. Whereas the original process had only one area for wastewater to enter the system, the step feed process distributes the oxygen intake throughout the basin. This is also the case with the complete mixing method, in which the wastes and bacteria are kept in similar quantities. This process allows for more variation in the amount of water entering the system (Benjes Jr., 18).

Attached growth systems rely on using a solid surface covered with biological growth, which the water is forced through or that is passed through the water. This method is usually favored for its simplicity, but it is not as effective as the activated sludge method. The method has found to been quite unreliable when predicting its performance however. Yet, there are always new ideas being developed, and some of the ideas concerning attached growth systems have been utilized and implemented in newer systems.

There are two types of attached growth systems. They include systems that use a stationary medium on which organisms grow, and a system where the medium is moving throughout the wastewater container. For the stationary systems, the medium is usually "rock, stacked plastic bundles, random-dumped plastic, and fabricated redwood stacked pallets" (Benjes Jr., 43). However, each material has its advantages and disadvantages. Rock is very difficult to transport, and it cannot be stacked upon itself to great depths due to instability. The plastics are most widely used, as they are cheap, light in weight, and have the greatest unit surface area per unit volume. The redwood pallets are also efficient, as they include several similar traits as that of plastic. This stationary system is dependent on the flow of liquids through the materials being used, so there is a need for

water from the system to be pumped back through the system. This process is called recirculating.

Water must first be applied to whatever material is being used to grow bacteria. The purpose of water is to keep the bacteria attached to the surface, as well as preventing dehydration of bacteria during times when the material is not under the surface of wastewater. In the majority of wastewater plants, this liquid is applied through a rotating distribution arm, which will provide greater aeration than through a stationary applicator. Also, the rate the water is applied will affect performance (Benjes Jr., 43).

Wastewater must first undergo primary treatment, which will remove debris and other easy-to-remove solids. However, in the past, this process was quite often overlooked, as the solids obtained are usually low in BOD. Another aspect of this system is that the performance is independent of the source of recirculated water into the system. This first type of attached growth system is frequently used in conjunction with an activated sludge process, with the latter acting as the next step in the treatment process (Benjes Jr., 44-45).

The rotating medium system depends on energy used on the movement of the medium through the water. This method, therefore, excludes the recirculation process. The material used is usually in the form of a disc, a lattice, or a container of plastic balls. The use of a disc is kept within small plants, while the lattice design is more commonly used in larger plants. The lattice provides advantages in surface area and structural design. The rotation of the material is provided by mechanical drives at most plants, while air-motivated rotation is also used at smaller plants.

While mechanically driven units have become widely common, the units require much attention and maintenance. These units also suffer from low levels of oxygen in the first stage of multistage treatments. Air-driven units are units that, while underwater, release oxygen by themselves that both move the unit through buoyancy and add oxygen to the liquid. The latter is a reason why this system is thought to be more efficient than the mechanical method (Benjes Jr., 46).

The Disinfection Process

First of all, disinfection is defined as the destruction of pathogens in the water sample. Throughout the history of water treatment, there have been many processes in which water can be disinfected. Each method, whether it is physical or chemical, has both advantages and disadvantages.

The physical methods of disinfection, including heat, sound and ultra-violet light, are found to be very cost inefficient. The use of heat is practical on a low scale, such as when the groundwater is contaminated for a household. However, the final product is deemed poor to taste and look. The sterilization of water by heat takes place at around 120 degrees Celsius.

Ultra-violet light and ultrasonic vibrations are both viable pathogen killers. Yet, these methods must be quite intensely utilized, as their lesser counterparts, radio waves and sunlight, have little to no effect in water sterilization. Ultra-violet light has several advantages, which makes it a somewhat popular method of the current time. The interaction of the ultra-violet rays, destroys bacteria in just seconds. Not only is it a quick process, but there is no loss to taste, and no worry of any chemical leftovers still

contained in the water. This process also has no detrimental effects on the environment.

The first chemical method of disinfection to be discussed is the use of hydrogen peroxide. This chemical's addition to water releases a powerful oxidant, which kills bacteria both harmful and harmless to humans. The excess chemical can be removed through filtration with the aid of manganese dioxide. This method is quite costly.

Ozone is another chemical commonly used for disinfection. It's not a surprise that ozone is effective, as it is created from oxygen molecules being split by ultra-violet rays. In the purification process, water trickles downward while ozonized air is forced upward through a tube. At low temperatures, this process is superior to chlorinization in effectiveness. Ozone also improves the color and sparkle of the water, reduces the amount of organic matter suspended in the water, and improves the taste and odor. Yet this process is expensive, corrosive, and leaves the user with no way to detect how much ozone is in the water.

The most commonly used methods of disinfection are the use of the halogens. Everyone has at one point in their life drunk water from a fountain or swam in a pool that was cleansed with chlorine. Chlorine began being widely used in 1908, and played a significant role in keeping soldiers healthy in the First World War. It still is the most commonly used disinfection method today, as its benefits are incomparable. It's cheap, efficient, and controls taste and odor. However, as chlorine interacts with the water, chemical reactions take place and form compounds containing chlorine. Some of these compounds are known to be harmful, such as chloroform.

Chlorine dioxide has frequently been looked at as a replacement for the use of just chlorine. Although the instability of the chemical makes it impossible to be transported,

it appears that chlorine dioxide is more efficient than chlorine treatment. It is a strong oxidizer, and is useful as a disinfectant for viruses and bacteria. The biggest advantage over chlorine is the fact that "Chlorine dioxide has the advantage that it will not directly react with organic material to form halogenated bi-products" (Bivings).

The excess lime method is also an effective process of sterilization. In this procedure, large amounts of lime, or calcium hydroxide, are added to the water. This addition causes the lime to react with any and all minerals in the water. These reactions cause an increase in pH to around 12-13. Now, the water stays at this pH for several hours, forcing nearly all bacteria, viruses, and parasites to be diminished. For the water is be useful by humans, the pH must be under 10. To achieve this number, the lime treated water is either mixed with a large amount of chlorine treated water, or re-carbonated using carbon dioxide. Both of these methods are efficient, although the re-carbonation might take slightly more time.

Common Odor and Taste Problems

When water possesses an odor, the taste is usually unpleasant as well. But in rare cases the bad taste may not be accompanied by an odor, this type of water is known as ferruginous waters. A basic approach to the elimination of odor and taste is hindered by difficulties in the measurement of the harmful materials involved.

For a long time taste and odor problems from chlorination was a serious source of trouble, but nowadays, with industries obeying strict controls, complaints are quite rare. There are times when volatile organics gain access to the water supply, either before or after chlorination. In this case strange odors and tastes may be produced.

There are many common taste and odor problems with drinking water. If your water smells or tastes like a swimming pool then it is probably the chlorine that is added to the water to disinfect it. Chlorine is the most common of the water treatment methods. Chlorine is very effective at killing bacteria and viruses, but at the same time causes a strange smell and odd taste in your drinking water. The addition of ammonia to produce monochloramine, which makes it last longer in pipes, make the smell and taste even worse.

Too much iron, manganese and other metals also change the appearance and taste of water. They may be produced by corrosion or naturally occurring. Water may be rust free when it leaves the treatment plant, but could pick up corrosive metals in the pipes on the way to your house. Untreated water from private wells usually contains iron and manganese in reduced forms, which is fully dissolved until slowly oxidized by oxygen in the air. This water will appear clear at first, but will turn rust-colored after a few minutes.

There is sometimes a musty or fishy taste and smell to drinking water. This is due to the presence of algae, bacteria and molds that live in some water sources. This smell and taste may be stronger during certain times of the year, when algae bloom in the lakes and rivers.

The rotten egg smell that so many people have experienced in water is caused by hydrogen sulfide in water. This hydrogen sulfide is produced by bacteria, which are found deep in wells and in water mains that are rarely used and stagnant. When combined with iron, iron sulfide can be highly corrosive and cause many other problems.

Water that is brownish in color can be caused by the extracts of dead leaves along with the corrosion of iron and manganese. This water is unpleasant tasting and looking

and also can stain sinks and laundry. Organic color and staining usually occurs in areas with poor drainage, these stains can be very difficult to get out.

Hardness of water can also be a problem for some people. This term has to do with water that has picked up minerals such as calcium and magnesium as it travels through rocks and soil. Hard water leaves a film on things and makes soaps and detergents lather up less. Water that is very hard has an extreme off-taste, yet moderate amounts taste pleasant to most people (James, 65-85).

Reducing Taste and Odor Problems

Most of taste and odor problems are easily solved with point-of-use water filtration systems containing activated carbon. The activated carbon surface attracts and holds tiny particles and molecules such as those that cause the most common tastes and odors. Better systems also can reduce other water contaminants that pose serious health threats, such as trihalomethanes and other volatile organic chemicals, lead, and parasites like Cryptosporidium.

Activated carbon filters are not the answer to all taste, odor, and color problems. When iron and manganese from wells and corrosion areas change to insoluble forms, good mechanical filters can easily remove them. However, it often is necessary to use small chlorinator pumps or special filters with oxidizing media in front of the mechanical filters to oxidize the iron or sulfite quickly.

POU systems designed for the consumer are typically the size of a household fire extinguisher. They are installed under the kitchen sink and dispense filtered water through a dedicated drinking water faucet (Danamark).

Contaminants Most Widely Found

- Coprostanol

Coprostanol is a fecal steroid found in the digestive tracks of mammals. If coprostanol is found at a location, it is an indicator of human wastewater contamination. According to Kruczynski, "It is a better indicator of discharge of untreated sewage because unlike fecal coliform bacteria which are relatively short-lived in the marine environment, coprostanol accumulates in sediments and provides a long-term record of sewage pollution. However, measurement of coprostanol is impractical for routine monitoring because it requires sophisticated, expensive analysis and, at the present time, there is no regulatory standard for coprostanol." So therefore, it is difficult to make a judgment concerning coprostanol, as it has appeared in several different studies, and there is not much one can do about it.

- N,N-diethyltoluamide

N,N-diethyltoluamide, also known as DEET, is used in topical insect repellent. DEET is very useful in deterring insects, especially ticks, and through this process, greatly cuts down on the number of cases of Lyme Disease. However, in certain cases, DEET can be harmful, or even lethal, to humans. Since the early 1960's, there have been

twelve cases of toxic reactions to the chemical. "Six girls, ranging in age from 17 months to 8 years, developed behavioral changes, ataxia, encephalopathy, seizures, and/or coma after repeated cutaneous exposure to DEET; three died. Another six systemic toxic reactions have been reported following ingestion of DEET." Also, it is included that several rangers from the Everglades who use the chemical on a regular basis had experienced ill side effects.

However, in 1989, five seizures were investigated, as they were believed to have been induced by DEET. All patients had used the chemical prior to the illness, all in different concentrations. Each person recovered quickly without any long term effects.

It is thought that DEET has some effect on the neurological behavior in children. Yet, over the past sixty years since DEET's first usage, there is very little evidence to support this claim. The aforementioned cases are the only to speak of, which can hardly imply that DEET will affect everyone. Overall, the side effects are unpredictable, and they cannot produce a pattern of DEET's usage for everyone. However, to have low concentrations of DEET in water supplies would be considered a potential danger. One of the biggest warnings on any repellent's label containing DEET would be not to ingest any of the chemical. So, just as the predictability of DEET causing a seizure is unknown, it's appearance in the water supply will also have unknown effects (Morbidity).

- Tri(2-chloroethyl) Phosphate

Also known as TCEP, Tri(2-chloroethyl) phosphate is a flame retardant, used mainly in liquid polyester resins and in textile back-coating formulations. Used in experiments with mice, TCEP was found to have adverse effects on the brain, liver, and

kidneys. It was also found to cause lethal mutations in rats (Tris). "Data indicating low environmental exposures support the conclusion that TCEP poses a very low risk of adverse health effects for the general population" (International). However, as this report is slightly dated, one can wonder if TCEP will have an effect on the environment or on humans. Although reports say that TCEP has been decreasing in usage, the levels of this chemical have increased in the past couple years. This will hopefully lead to a new study done on this flame retardant.

- Triclosan

Triclosan is a chemical used in several personal care products, such as soaps, detergents, deodorants, and toothpaste. Triclosan is also a man made chemical, which lends to it several properties that are unwanted. Its chemical structure classifies it as a polychloro phenoxy phenol, which will produce dioxins and dibenzofurans. Both of these by-products are considered to be toxic.

What is more interesting is that triclosan produces these by-products under certain conditions. They can depend on either pressure or temperature. However, the toxicity of these chemicals depends more so on the level of chlorine they have to react with. "Those dioxins and dibenzofurans that have chlorine atoms at the 2,3 and 7 positions are particularly toxic. Tetrachlorodibenzo-p-dioxin and tetrachlorodibenzo-furan, which have chlorine atoms at the 2,3,7, and 8 positions, are considered the most toxic of the dioxins and dibenzofurans, with 2,3,7,8-tetrachlorodibenzo-p-dioxin referred to as one of the most toxic substances known" (Menoutis).

- Nonylphenols & Octylphenols

(Includes 4-nonylphenol, 4-nonylphenol monoethoxylate, 4-nonylphenol diethoxylate, 4-octylphenol monoethoxylate, 4-octylphenol diethoxylate, 4-methyl phenol)

4-Nonylphenol and 4-Nonylphenol Monoethoxylate are environmental estrogens. Both are also known as EDCs, or endocrine disrupting chemicals. There are several studies that have been conducted on 4-nonylphenol, all of which speak negatively of the chemical. The endocrine system is responsible for communication between cells, and for releasing hormones in bodies. When this system is disturbed, the cells malfunction, causing changes in anything from growth to reproduction (Stephens).

In one study, scientists experimented with spraying an insecticide called Matacil 1.8D over the Western coast of Canada near the Atlantic Ocean. This insecticide contained a significantly large amount of 4-nonylphenol. The results of the study were that a lot less salmon showed up year-by-year, depending on the amount of the chemical they sprayed. The chemical also produced negative effects on the ability of salmon to swim from fresh water to salt water. Another study showed that 4-nonylphenol had detrimental effects on crustaceans as well, causing problems in the animals' reproductivity (Leblanc et al).

These chemicals are considered together, as the additional suffixes are just a description of how the atoms are connected. Reports have stated that there are numerous different strains of the 4-nonylphenol chemical, including strains that have been banned in many countries for their toxicity to animal life. Octylphenols are also examples of EDCs, which puts them in the same category as nonphenols. These chemicals have been shown to cause chemical imbalances in snapping turtles as well as fish (Trudeau). It can

be safely stated that any member of this group of EDCs will cause detrimental effects in the environment.

- Bisphenol-A

Bisphenol-A is a widely used chemical found in anything from polyester resins, pesticides, herbicides, or sealants used by a dentist for human teeth. It is also used for lining the inside of aluminum cans, and for producing most consumer plastics. However, there are several studies that show that having this chemical in large abundance in our environment could affect all sorts of living organisms (Colborn).

Bisphenol-A has been found to have effects on prostate cancer cells in humans, causing the disease to become untreatable after exposure in small quantities. It has also initiated prostate and breast cancer instances in rats, as well as increased the speed of sexual reproduction and obesity. Bisphenol-A is yet another EDC.

- Carbaryl

Carbaryl is a wide-spectrum carbamate insecticide which controls over 100 species of insects on citrus, fruit, cotton, forests, lawns, nuts, ornamentals, shade trees, and other crops, as well as on poultry, livestock and pets. This general use pesticide is moderate to very toxic, it is extremely harmful if touched by human skin, inhaled, or ingested. Inhalation or digestion of carbaryl in large amounts can lead to nausea, stomach cramps, diarrhea, and salivation. Direct contact to the eyes or skin can cause severe burns. Some other symptoms at high doses include blurred vision, sweating, and convulsions. About fifty cases of occupational or accidental illnesses due to exposure to

carbaryl have been reported, but no fatalities have been documented. The only documented fatality from carbaryl was through intentional ingestion.

Carbaryl has a short residual life on treated crops. The pesticide stays at the point of application until it is slowly taken into the plant and metabolized. Insecticidal properties are retained for 3-10 days. Loss of carbaryl is due to evaporation and uptake into plants. Breakdown by sunlight does not appear to be significant. Degradation of carbaryl in the soil is mainly due to sunlight and bacterial action. It is bound by organic matter and is transported by the soil runoff. Carbaryl has a half-life of seven days in aerobic soil and one of 28 days in anaerobic soil. The metabolites of carbaryl have lower toxicity to humans than carbaryl itself. The breakdown of this substance is strongly dependant on acidity and temperature.

Carbaryl is broken down in pond water by the chemical processes of bacteria. Carbaryl has a half-life of from 1 to 32 days in pond water. In a stream, carbaryl that had washed in from forest spraying decayed to 50 percent within a 24 hour period. It has been shown to degrade more slowly in the presence of mud in aquatic habitats. Carbaryl has been detected in groundwater in three separate cases in California (Extoxnet).

- Phthalic Anhydride

Phthalic Anhydride is used for many things. For one it is used in the manufacture of alkyd resins for paints and varnishes. It is also used in the manufacture of unsaturated polyester resins. Phthalic Anhydride is also finds application as Dye intermediate and also in the manufacture of pigments. Anthraquinone and its derivatives are used in dyes

and pigments like Phthalocyanines are used as coloring agents in laminates varnish, printing ink and plastic industries. Phthalic Anhydride is used in the manufacturing of Tetrachloro Phthalic Anhydride which finds applications in reactive fire retardant in unsaturated polyesters.

When Phythalic Anhydride makes contact with water pythalic acid is formed, which can be the cause of many corrosive effects. These effects may be delayed several hours. There are many potential health effects that can be brought about by Phythalic Anhydride, these are brought about by inhaling, ingesting, eye contact, and skin contact.

Inhalation of vapor, fume or dust is a primary irritant. Coughing, choking, as well as headache and dizziness can occur. Allergic respiratory reactions may also occur. Swallow this harmful material can cause burning of the throat, mouth, and stomach. This can lead to a sore throat, vomiting, and diarrhea. If one touches Phythalic Anhydride redness can occur, along with a severe burn and sometimes allergic skin reactions. If one gets it in the eye, Conjunctival edema and corneal destruction can occur. Some symptoms include pain, tearing, and photophobia. Chronic exposure by inhalation or skin contact can cause allergic sensitization. Liver and kidney effects were also found in laboratory animals. People with pre-existing skin disorders or impaired respiratory function may be more susceptible to the effects of this substance than others.

- Sulfamethoxazole

Sulfamethoxazole is a member of the sulfonamide family of antibiotics. It is used for people with infections caused by a variety of bacteria and protozoa. The combination

drug product trimethoprim/sulfamethoxazole (TMP/SMX) is used to treat a wide variety of bacterial infections and some infections due to parasites (Healthnotes).

Some common side effects of taking this antibiotic include, an upset stomach and sensitivity to light. Some other common side effects include, nausea, vomiting, headache, and loss of appetite. There are rare cases when the following occur to people: skin rash, difficulty breathing, itching, hives, chills, fever sore throat, aching of joints or muscles, easy bleeding or bruising, yellowing of the eyes and skin, peeling skin, and tiredness. To manage these side effects one should drink lots of high calorie fluids such as cranberry juice and nectars. One should drink up to two quarts daily to make sure there is an adequate volume of urine to prevent dehydration. Sulfamethoxazole should also be taken with milk to minimize GI irritation (Access).

- Lincomycin

Lincomycin belongs to the family of medicines called antibiotics. These medicines are used to treat infections. They will not work for colds, flu, or other virus infections. It is effective against most gram-positive organisms including staphylococci, some streptococci, and anaerobic bacteria of the genus Clostridium. The presence of severe kidney disease, liver disease, or stomach and intestinal disease may affect the use of lincomycin. In some patients this antibiotic may cause abdominal or stomach cramps and pain, abdominal tenderness, fever, and diarrhea, which may also be bloody. Nausea and vomiting is also a common side effect of lincomycin. Skin rashes, redness, and itching; sore throat and fever; unusual bleeding and bruising are some less common side effects (National).

- Estriol

Estriol is produced in large quantities during pregnancy and can be used as an indicator of fetal well-being and to predict preterm labor. Estriol is the most abundant of the estrogens and is thought to have anti-breast cancer effects (Pharmasan).

Estriol has been found to provide some of the protection without the risks associated with stronger estrogens. Depending upon the situation, estriol may exert either agonistic or antagonistic effects on estrogen. Estriol appears to be effective at controlling symptoms of menopause, including hot flashes, insomnia, vaginal dryness, and frequent urinary tract infections. Results of research on its bone-density-maintaining effects have been contradictory, with the most promising results coming from Japanese studies. Estriol's effect on cardiac risk factors has also been somewhat equivocal; however, unlike conventional estrogen prescriptions, it does not seem to contribute to hypertension. Although estriol appears to be much safer than estrone or estradiol, its continuous use in high doses may have a stimulatory effect on both breast and endometrial tissue.

Of the three estrogens (estradiol, estrone and estriol) only estriol does not encourage cancer. Dr. Allan H. Follingstad, in an article in the Journal of the American Medical Association, called estriol the "forgotten estrogen," and he said that any women in a high-risk category (such as a family history of breast cancer, prior dysplia or fibrocystic disease of the breast) should have the option of taking estriol rather than other types of estrogens.

Estriol has a much less stimulating effect on the breast and uterine lining than estradiol and estrone. Estradiol is 1000 times more stimulating to the breast tissue than is estriol. An exciting thing about estriol is the fact that not only does it not promote breast cancer, but considerable evidence exists to show that it protects against this disease.

High levels of estriol have been found in vegetarians and in Asian women who consistently appear to be at much less risk of breast cancer. Research has demonstrated that women with breast cancer have a reduced excretion of estriol (Head).

- Erythromycin-H2O

Erythromycin is an antibiotic used to treat a wide variety of bacterial infections, such as respiratory tract infections, middle ear infections, and skin infections. Erythromycin is particularly useful in individuals allergic to penicillin. Erythromycin is generally well tolerated. It is thought that it can be used safely in pregnancy and during breast-feeding.

There are some uncommon side effects. Gastrointestinal disturbance, liver reactions, allergic reactions, hearing loss, and irregularities of the heartbeat have been reported (New Zealand).

Some research has shown that giving young infants the antibiotic erythromycin, particularly in the first two weeks of life, raises their risk of a gastrointestinal complication that may require surgery. Investigators also found a possible association between a complication called infantile hypertrophic pyloric stenosis (IHPS) and a mother's use of certain antibiotics in the last 10 weeks of pregnancy.

IHPS occurs when the pylorus, a tube leading from the stomach to the small intestine, becomes enlarged. This blocks the stomach's outlet and causes projectile vomiting and subsequent weight loss and dehydration in infants. IHPS normally arises when babies are about one month old and it is the most common cause of abdominal surgery in infancy. In most cases, the newborns were given the antibiotic because their mothers had chlamydia infections (Mercola).

- Tetrachloroethylene

Tetrachloroethylene is a colorless liquid solvent with a sweet chloroform-like odor, widely used for dry cleaning and metal degreasing. It is also used in the production of other chemicals, mostly for chlorofluorocarbon. The chemical is used in smaller quantities in rubber coatings, solvent soaps, printing inks, adhesives and glues, sealants, polishes, lubricants, and pesticides.

Tetrachloroethylene may be a carcinogen in humans and may damage the developing fetus. Exposure to high concentrations of it in air, particularly in poorly ventilated areas, can cause dizziness, light-headedness, nausea, confusion, difficulty in speaking and walking, possibly unconsciousness, and death. Overexposure can cause the heart to beat irregularly or stop.

Tetrachloroethylene can also damage the liver and kidneys enough to cause death. Breathing the vapor may irritate the lungs, causing coughing and/or shortness of breath. Higher exposure can cause a build-up of fluid in the lungs, which can cause death. Contact with the liquid can cause severe skin burns, and can cause eye burns. It may damage the liver and kidneys with high single exposures or lower repeated exposures.

Long-term exposure can cause drying and cracking of the skin. Exposure to the vapor can irritate the eyes, nose, mouth, and throat.

It is estimated that nearly 500,000 U.S. workers are at risk of exposure to tetrachloroethylene at over 20,000 dry-cleaning establishments and at a large number of other industries manufacturing or using the chemical. Populations at high risk of exposure to the chemical include those living in the vicinity of dry-cleaning operations, factories that emit tetrachloroethylene, and chemical waste dumps (Environmental).

- Acetaminophen

Acetaminophen is a pain and fever-reducing medication. Acetaminophen is sold under Tylenol and other brand names and has dangerous side effects that most people are not aware of. Many people either use this class of drug chronically or take higher-than-recommended doses, not realizing that they are causing liver, and kidney damage. The long-term use of acetaminophen medications can cause other problems as well.

Acetaminophen is one of the more potentially dangerous analgesic drugs. An intentional overdose can be fatal, and chronic use may cause liver and kidney damage. When a person takes acetaminophen, it is metabolized by a number of metabolic systems in the liver, including one called the P450 system. This results in an intermediate by-product, or metabolite, that is very reactive and can kill liver cells. This intermediate metabolite is normally converted to a harmless final metabolite by an antioxidant in the liver called glutathione. A large dose of acetaminophen reduces the glutathione supply, resulting in progressive necrosis of the liver, sometimes evidenced in as little as 5 days. Alcoholics and those on certain medications that stimulate the P450 system are at

particular risk because, with increased P450 activity, more toxic intermediate is created than there is glutathione available to further metabolize it to something harmless. Although not fatal, chronic acetaminophen use decreases the functional capacity of the liver.

Acetaminophen can also cause permanent kidney damage when taken over extended periods of time. This damage can be lethal to those with underlying kidney disease. The Food and Drug Administration does not require the manufacturers of Tylenol and other brands of acetaminophen to adequately warn people with kidney disease to avoid this pain medication. However, for those in chronic pain who cannot find relief from natural pain relief therapies, it is suggested that Tylenol and other brands of acetaminophen be used sparingly.

To illustrate how dangerous acetaminophen can be, one study showed that people who used acetaminophen with other pain relievers on a regular basis had a three- to eightfold increase in their risk of kidney cancer. Kidney cancer is very difficult to treat. The liver-kidney-heart muscle toxicities and the cancer risks of analgesic drugs have not been reported by most media sources, which reap tremendous profits from the advertising of pain relief products.

Acetaminophen poisoning is a toxic reaction resulting from the ingestion of excessive doses of the drug. In adults, dosages exceeding 10 to 15 grams can produce liver failure and dosages exceeding 25 grams can be fatal. Symptoms such as nausea and vomiting, profuse sweating, pallor, and oliguria (scanty amounts of urine) are associated with the onset of acetaminophen poisoning. Jaundice and pain in the upper abdomen,

hypoglycemia, encephalopathy, abnormal functioning of brain tissue, and kidney failure may become apparent as drug toxicity increases (Life).

- Diazinon

Diazinon is the nations #2 best selling home and garden insecticide. The primary uses for this insecticide are as follows:

- Outdoor application by homeowners (39%)
- Lawn care operators (19%)
- Exterminators (11%)
- Flea and Tick collars

The largest food uses are listed below:

- Almonds (170,000 lbs)
- Pecans (85,000 lbs)
- Prunes (66,000 lbs)
- Plums (64,000 lbs)
- Peaches (61,000 lbs)
- Sweet Corn (48,000 lbs)

Diazinon is one of a class of pesticides called organophosphates (OPs), chemicals that were originally developed by the German company I.G. Farben as nerve gases during World World II. Even short-term exposure to diazinon and other OPs can damage the brain and nervous system. Symptoms can range from headaches, nausea, dizziness, and seizures to paralysis, multiple chemical sensitivity syndrome, comas, and death in

extreme cases. Pesticide industry studies conducted on laboratory animals show that children are more susceptible to diazinon than are adults.

After reviewing thousands of scientific studies--most of which were generated by the pesticide industry--the EPA concluded in June 2000 that all common household uses of diazinon are unsafe (Environmental).

Diazinon is the most frequently detected insecticide in US Geologic Survey's National Ambient Water Quality Assessment (NAWQA) program. It is found in 24 states plus the District of Columbia, including every major river basin. Diazinon has been found in drinking water wells at levels exceeding EPA's 'safe' level. Diazinon could contribute to unsafe drinking water exposures for children.

Runoff of diazinon has reached unsafe levels in Northwest watersheds creating a threat to salmon populations. Diazinon interferes with juvenile Chinook salmon's ability to detect alarm chemicals in the water leaving them vulnerable to predator attacks. Since diazinon is a broad spectrum insecticide, it also impacts the insects and other animals on which the young salmon feed. The dose of diazinon inhibits reproductive behaviors and may also cause genetic damage in fish. The EPA has come under a lawsuit for failing to develop a plan to safeguard salmon from pesticides under the Endangered Species Act.

There are some stories of Diazinon victims throughout the country. One such story involves two female gardeners in Singapore knocked over a container of diazinon. After cleaning up the spill, one of the women experienced diarrhea, dizziness, frothing at the mouth, and pulmonary edema requiring a respirator. She later developed acute pancreatitis.

A couple other stories are also quite disturbing. An 18 month old boy in Michigan was accidentally fed "roach milk" (5% diazinon). The boy was taken to the hospital in a coma. He recovered with treatment. A six-year-old girl had her hair washed for head lice with diazinon. She was hospitalized after full cardiac and respiratory arrest. Diazinon has been cited in more than 200 lawsuits involving acute poisonings, chronic conditions and at least one death (Environmental).

- 1,4-Dichlorobenzene

1,4-Dichlorobenzene is a colorless solid with a mothball-like odor. It is used as moth repellent, general insecticide, pesticide, air deodorant and chemical intermediate for dyes. It is moderately toxic to humans. It is a priority environmental pollutant listed by the Environmental Protection Agency (Liu).

- Trimethoprim

Trimethoprim is an antibacterial drug used to treat people with urinary tract infections and upper respitory infections. TMP is used to treat a wide variety of bacterial infections due to parasites. TMP, in a combination form with Sulfamethoxazole (SMX) is also given to people with HIV.

Some side effects of this drug are bleeding, headache, skin rash, itching, alteration in taste, sore mouth or tongue, anorexia, diarrhea, nausea, vomiting, abdominal pain, and cramping. High doses of trimethoprim may cause hyperkalemia, which is abnormally high levels of potassium in the blood. The drug impedes the passage of potassium into the urine (Access).

- Pyrene

Pyrene is one of a group of chemicals called polycyclic aromatic hydrocarbons, PAHs for short. PAHs are found naturally in the environment but they can also be man made. Pyrene is a colorless crystal-like solid, but it can also look yellow. PAHs are created when products like coal, gas, oil, and garbage are burned but the burning process is not complete.

Like most PAHs, pyrene is used to make dyes, plastics, and pesticides. One of the most common ways pyrene can enter your body is through breathing contaminated air. If you eat or drink food and water that are contaminated with PAHs, you could be exposed. Once in your body the PAHs can spread and target fat tissues. Target organs include kidneys, liver, and fat. However, in just a few days, it will leave through your urine and feces.

Animal studies have shown that mice that were fed pyrene developed nephropathy, a kidney disease. A decrease in weight of the kidney and an increase in weight of the liver have also been seen. Slight alterations in the blood have also been detected.

A number of PAHs have caused tumors in laboratory animals when they were put in their food supply, in their air supply, and also applied to their skin. When pregnant mice were expose, there were reproductive problems. The offspring showed signs of birth defects and a lowered body weight. Other effects include damage to skin and immune system complications. These effects have not been found in humans thus far.

The U.S. Environmental Protection Agency, EPA, has indicated that not enough information exists to classify pyrene as a cancer causing substance (Agency).

- Fluoranthene

Fluoranthene is found in fossil fuels and occurs in products of incomplete combustion. It has been detected in mainstream cigarette smoke, urban air, gasoline engine exhaust, emissions from burning coal and from oil-fired heating, in soils, groundwater, and surface waters at hazardous waste sites (Risk).

Fluoranthene was tested for carcinogenicity by skin application on mice in two studies, and no tumorigenic effect was observed. When fluoranthene was administered to mice by skin application together with benzo[*a*]pyrene, an excess of skin tumours was produced over that induced by the same dose of benzo[*a*]pyrene alone. Fluoranthene was also mutagenic to salmonella typhimurium and to cultured human lymphoblastoid cells in the presence of an exogenous metabolic system. There is limited evidence that fluoranthene is active in short-term tests.

Fluoranthene is present as a major component of the total content of polynuclear aromatic compounds in the environment. Human exposure to fluoranthene occurs primarily through the smoking tobacco, inhalation of polluted air and by ingestion of food and water contaminated by combustion effluents (Fluoranthene).

Effects on Fish and Wildlife

The effects of pollutants on fish varies greatly with the season. During the winter, when the water is very cold, fish are extremely resistant to the effects of pollution. This

is due to their low respiration rate and the higher oxygen content of the water during this season. The rapid rise in water temperature in the spring brings on a critical period when fish are susceptible to unfavorable conditions and often die. Again in late summer and early fall, when high water temperatures are attained, the fish show reduced resistance to low oxygen and other effects of pollution. Because of this increased rate of respiration and low dissolved oxygen which occurs only under these critical conditions, fish deaths in lakes and streams are usually confined to a few days of the year when the weather is very warm and the water level low (Nemerow, 195-196).

Most harmful effects of pollution on fish life pass unnoticed or are attributed to other causes than pollution when the fish are slowly killed off. Some pollutants only kill of the small ones and the dead may not be seen. Or the spawn may be prevented from hatching, or the development may be made abnormal, so that malformed fish may result. The pollutant may also kill the animal life on which the fish normally live, thus depriving them of nourishment. Fish then tend to become dwarfed in polluted waters. Certain chemicals even in minute quantities have been known to affect the taste of fish, which prevents their sale.

Fish unquestionably show a negative reaction towards water badly polluted with wastes, for they swim away from the wastes. Extremely small concentrations of certain chemicals have been found to make fish very nervous, rendering them as easy pray for other aquatic life or driving them away from the waters.

The incidence of disease increases among fish in polluted waters. Parasitic worms produce little black cysts on the skin of fish in polluted waters more commonly than in most unpolluted water.

The Water Quality Criteria emphasize that the time-concentration relationship is very important in all studies of tolerances of aquatic life toward pollutants. Some of the variables to be considered in setting up water criteria for fish propagation are:

- The effects of harmful substances vary with species, size, age, and the physiological conditions of the individual.
- The effects vary with the physical and chemical composition of the water supply. For example, in soft water the damaging effects of poisons are generally greater than in hard water. The interrelationships between the dissolved constituents of the water supply are also extremely important. By synergistic action the combined influence of several substances simultaneously may result in greater damage to the fish life than the sum of individual effects taken independently.
- Hydrographic features of water courses and fluctuating water levels, particularly in impoundments, may also modify the effects of pollutants on fish in their natural habitats (Nemerow 196-198).

Synthetic detergents have caused much concern over the past few years. They have a tendency, even in small amounts to cause foam on rivers and other water sources. They also reduce the rate of re-aeration of river waters, adversely affect the efficiency of sewage purification plants, may cause taste in water supplies and are toxic to aquatic flora and fauna. Some anionic and non-ionic detergents can kill certain fish in 5-100 hours though certain species can to some extent become acclimatized to the detergents. There has been research comparing natural detergents with synthetic detergents as regards their toxicity towards fish.

While the natural detergents exhibit very greatly reduced toxicity in hard water, the synthetic detergents show the same toxicity in distilled water and in hard water. Water plants, as well as water animals, can be adversely affected by detergents. Laboratory experiments have shown that the rooted plants Ranunculus aquatilis, Potamogeton pectinatus, and Potamogeton densus are unable to grow in a small amount of detergent. Addition of anti-foam agents does no reduce the toxicity of the detergents toward these plants.

One unexpected result of pollution caused by detergents has been reported in the U.S.A. where mortality amongst ducks has occurred in certain waters receiving these detergents. The normal protective oily coating on the duck feathers tends to be dissolved by detergents, thus causing the feathers to become waterlogged and the ducks to be drowned (Klein 33-34).

Any appreciable amount of toxic inorganic compounds may hinder or even prevent self-purification of rivers and may kill fish and other aquatic life whether animal or vegetable. Recent work shows that the toxicity of fluorides to rainbow trout in softened water is quite considerable. Thus, at 55 F, the lethal concentration to 50% of the fish was between 2.6 and 6.0 p.p.m. of F. Also temperature increase causes some increase in toxicity. Hard water would make fluoride less toxic due to the precipitation of the F as insoluble Ca and Mg fluorides. The toxicity of F appears to be due to its ability to inhibit certain essential enzyme-catalyzed reactions.

A considerable amount of work has been done on the experimental determination of the toxicity of various substances towards fish and attempts have been made to express the results in terms of a threshold concentration or minimum lethal concentration.

It is important to remember that the effect of toxic substances on fish food may be a vital factor in determining whether fish can flourish or survive in a polluted stream, as in many cases the lower organisms upon which fish depend for food are even more susceptible to a poison than are the fish themselves (Klein 39-42).

Since World War II, a large number of pesticides have been developed which have tended to replace the older chemicals and we are finding increasing and extensive application for agricultural and other purposes. Unfortunately, some of these compounds are extremely toxic to birds, mammals, and fish and their widespread and uncontrolled use of pesticides and weed-killers can cause pollution of the streams and fish mortality, especially after rain.

It has been reported that in surface waters of southwest Oklahoma heavy losses of fish occurred after cotton fields had been sprayed with insecticides containing aldrin and toxaphene. Toxic concentrations of aldrin can persist in streams for many days. In a survey of fish mortalities conducted by the U.S. Public Health Service in a 31 state area, agricultural pesticides accounted for the largest number fish kills (Klein, 126-128).

With insecticides now in suck extensive use, serious problems are occurring. The primary site of the lethal action of DDT in insects is the nervous system and the nature of the action appears to be an unstabilizing effect similar to that produced by a lack of calcium ions. In mammals also, the central nervous system is affected, the first symptom of DDT poisoning being tremor of the skeletal muscles. Fish poisoned by DDT are first excited and the exhibit ataxia and paralysis. Later they die on their sides with tremors and convulsions.

Studies have been done on the toxicity of 7 insecticides of this type to rainbow trout. The symptoms noted were similar to the ones just described and a further marked feature was blanching of the skin caused by concentration of the melanophores. The organic phosphate insecticides are believed to be less dangerous to fish than the chlorinated hydrocarbons because they are less stable, as some of them break down in water.

Examples of this group are malathion, parathion, TEPP, EPN, chlorothion, diazinon, dipterex, and demeton. It has been shown that these compounds have an inactivating effect on the nervous system of fish and thus inhibit the transmission of nerve impulses.

Some of the older insecticides are toxic to fish. One of these is derris, whose active ingredient is rotenone. This has been known to be a fish poison for centuries. Rotenone enters the body of the fish through the gills to act as a paralytic nerve poison. Derris is generally regarded as a very safe insecticide and there is ample evidence of its low toxicity to man and other mammals. There is some risk of this leading to carelessness in its use and its harm to fish should not be forgotten. Potassium permanganate can be used to counteract its effect, but care must be taken since this too is also fish poison. Pyrethrins are also very toxic to fish and invertebrates although they are very safe insecticides for use with birds and mammals. Nicotine is so volatile that there is little danger of serious water pollution arising from its use (Klein, 268-271).

These are just a few of the harmful effects of contaminants on our water dwellers. There are limitations for the amount of harmful material that can be used at and around

bodies of water, but there has to be something more done to assure the safety of our fish, plants, and certain mammals.

How Can Contaminated Water Affect Us?

Uncontaminated drinking water is an essential component to human health and survival. Consumption of contaminated water over a long period of time can cause physical infirmities ranging from digestive dysfunction to nervous system disorders, cancer, and even death.

One such instance in Walkerton, Ontario of waterborne, bacterial gastroenteritis by multiple pathogens, shows how harmful water contamination can be to humans. Of the 4900 residents of Walkerton, 1346 (or 30% of the total population) became sick with gastroenteritis and 2300 people overall (including nearby towns) became infected by the contaminated water. Gastroenteritis is diagnosed by the presence of diarrhea, or bloody diarrhea. A total of 1000 people were admitted to the hospital's emergency ward, and six individuals died (Luck).

Another area of concern is the Great Lakes of the United States, which were heavily exposed to contamination several decades ago. The contamination is now in the form of sediment, which directly affects any organisms that live or feed on the bottom of the waterbed. Since each organism bioaccumulates chemicals during its lifecycle, the effect magnifies as one moves up the food chain. So the process begins with microscopic organisms and moves along up to the larger aquatic organisms such as fish. This has

sparked several studies in the area to produce guidelines for fish consumption from any of the Great Lakes.

Most of the contaminants of the Great Lakes were of the groups of pesticides, including chlordane, dieldrin, DDT and its metabolites. Other dangerous contaminants include the dioxins and furans, mercury, and certain chemicals of the –phenyl group, both the polybrominated biphenyls and polychlorinated biphenyls. These chemicals, similarly, were used and discarded at a point in time when nothing was known of their effects. Now, each Great Lake has been so heavily polluted to the point where time has very little effect on the decomposition of these chemicals (Great Lakes Commission).

What is the source of all these chemicals in our water? It could be attributed to wastewater techniques that do not remove or account for these lesser known chemicals. Or could some, or most, of these contaminants be contained in the sludge that is being redistributed across the U.S. for other purposes?

It can be seen that while these contaminants might not be exactly the same as chemicals that previously caused environmental problems, they still pose similar problems. Some contaminants are of similar chemical composition, while others produce bi-products of chemicals that have been banned by the government in the past. Overall, the ecosystem would be a lot better off without the pollution we are producing.

The problem we are facing cannot be solved immediately. It will take much more research and experimentation with some of the chemicals, while others will linger around until we discover a way to purge them from our environment. Some of the contaminants

found possess extremely dangerous side-effects, and these chemicals should be analyzed thoroughly to discover ways to neutralize or destroy them.

Access Project, "Sulfamethoxazole (Gantanol, Urobak)." 26 Jun. 1996. <www.aegis.com/factshts/network/access/drugs/sulfame.html>

Access Project, "Trimethoprim (Proloprim, Trimpex)." 26 Jun. 1996. <http://www.atdn.org/access/drugs/trim.html>

Agency For Toxic Substances and Disease, "Pyrene." 4 Aug. 2002. <http://www.epa.gov/epaoswer/hazwaste/minimize/pyrene.pdf>

Benjes Jr., Henry H., Handbook of Biological Wastewater Treatment. Garland Publishing, Inc., 1980

Bivings Group, "Highlighting the use of Chlorine Dioxide for water treatment and disinfection." 10 Jun. 2002. <http://www.clo2.com/>

Colborn, Theo, "Some Recent Important Studies of Bisphenol A." 10 Sept. 2002. <http://www.ourstolenfuture.org/NewScience/oncompounds/bisphenola/bpauses.htm>

Culp, Gordon L., Handbook of Sludge Handling Processes, Garland Publishing, Inc., 1979.

Danamark, "Taste, Odor, and Color in Drinking Water." 14 Nov. 2002. <http://www.danamark.com/Taste_Odor_and_Color.htm>

Environmental Working Group, "Environmental Working Group Fact Sheet on Diazinon." Jul. 1998. <http://www.ewg.org/reports/diazinon/facts.html>

Environmental Protection Agency, "Tetrachloroethylene Chemical Backgrounder." 7 Aug. 2002. <http://www.nsc.org/library/chemical/Tetrachl.htm>

Environmental Working Group, "Why is Diazinon Dangerous?" Jun. 2000. <http://www.ewg.org/reports/diazinon/danger.html>

Extoxnet, "Carbaryl." Sept. 1993. <http://pmep.cce.cornell.edu/profiles/extoxnet/carbaryl-dicrotophos/carbaryl-ext.html>

"Fluoranthene." 17 Apr. 1998. <http://193.51.164.11/htdocs/monographs/vol32/fluoranthene.html>

Great Lakes Commission. "Drinking Water in the Great Lakes." 18 March 2002. <http://www.great-lakes.net/humanhealth/drink/>

Gulbrandsen, "Municipal Wastewater Treatment." 11 Nov. 2002. <http://www.gulbrandsen.com/industries/munwaste.html>

Head, Kathleen A., N.D., "Estriol: Safety and Efficacy." 9 Sept. 2002. <http://www.thorne.com/altmedrev/fulltext/estriol3-2.html>

Healthnotes, "Sulfamethoxazole." 2 Aug. 1999. <www.healthwell.com/healthnotes/Drug/Sulfamethoxazole.cfm>

International Union of Pure and Applied Chemistry, "Flame Retardants: Tris(chloropropyl) Phosphate and Tris(2-chloroethyl) Phosphate, Environmental Health Criteria No. 209." 14 Feb. 2000. <http://www.iupac.org/publications/ci/2000/march/new_flame.html>

Klein, Louis, River Pollution II: Causes and Effects. Butterworth & Co. Limited, London, England. 1962.

Leblanc, Gerald A. et al, "Embryotoxicity of the Alkylphenol Degradation Product 4-Nonylphenol to the Crustacean *Daphnia magna.*" 2 Nov. 2000. 20 Nov. 2002. <http://ehpnet1.niehs.nih.gov/docs/2000/108p1133-1138leblanc/abstract.html>

Life Extension, "Acetaminophen Poisoning (Analgesic Toxicity)." 5 Dec. 2001. <http://www.lef.org/protocols/prtcl-001.shtml>

Liu, Jiangbi, "1,4-Dichlorobenzene Pathway Map." 15 Jul. 2002. <http://umbbd.ahc.umn.edu/dcz/dcz_map.html>

Luck, Jennifer et al. "Human Health." 12 June 2002. <http://www.nrs.mcgill.ca/whalen/hogs/first.web.page.htm>

Menoutis, J., Ph.D., F.A.I.C., C.P.C. and A. I. Parisi, "Technology Review Series Triclosan and Its Impurities." 9 Oct. 2001. <http://www.quantexlabs.com/triclosan.htm>

Mercola, Dr. Joseph, "Erythromycin Dangerous for Infants." Sept. 2001. <http://www.mercola.com/2001/oct/27/erythromycin.htm>

Morbidity and Mortality Weekly Report. "Epidemiologic Notes and Reports Seizures Temporally Associated with Use of DEET Insect Repellent -- New York and Connecticut." 6 Oct. 1989. <http://www.cdc.gov/mmwr/preview/mmwrhtml/00001475.htm>

National Library of Medicine, "Lincomycin." 29 Nov. 2002. <www.nlm.nih.gov/medlineplus/druginfo/lincomycinsystemic202328.html>

Nemerow, Nelson Leonard, Scientific Stream Pollution Analysis. Scripta Book Company, New York. 1974.

New Zealand Dermatological Society, "Doctors in Primary Care." 7 Nov. 2002. <http://www.dermnetnz.org/index.html>

Pharmasan Inc., "Estriol." 12 Apr. 2000.
<www.thehormoneshoppe.com/lab/estriol.htm>

Risk Assessment Information System, "Toxicity Summary for Benzo[B] Fluoranthene." 29 Aug. 1997. <http://risk.lsd.ornl.gov/tox/profiles/benzob.shtml>

Stephens, Mark, "Study sheds light on Atlantic salmon stock returns." Sept.-Oct. 1999.
<http://www.unbsj.ca/sase/biology/fishlab/news/oceans.htm>

"Tris(2-chloroethyl) Phosphate" 13 Apr. 1999.
<http://193.51.164.11/htdocs/monographs/vol48/48-06.htm >

Trudeau, Vance L. et al. "Octylphenol (OP) Alters the Expression of Members of the Amyloid Protein Family in the Hypothalamus of the Snapping Turtle, *Chelydra serpentina serpentine*." 12 Feb. 2002. 21 Nov. 2002.
<http://ehpnet1.niehs.nih.gov/docs/2002/110p269-275trudeau/abstract.html>