Free Range Bulletin 03/04:

'What does not kill them makes them stronger' – The Hazards of Anti-Bacterial Agents

Free Range Bulletin 03/04, by the Free Range Network, December 2003
http://www.fraw.org.uk/rangers/index.shtml

'Clean is good'. The rule that dominates our technological society. But is it really true? Are some of the products we use to make our homes clean making us sick instead? In particular, is the sale of 'anti-bacterial' agents – in cleaning solutions and even toothpaste – a positive hazard to our health? Does Triclosan clean us, or does it damage our health?

Kill them! Kill them all!

Bacteria are bad! Bacteria are a hazard and make you sick! We are constantly plied with this message through advertising, and through the sale of chemical compounds that make our lives cleaner. Then, in the 1990s, we went beyond 'clean' – we went 'anti-bacterial'. Our cleaners didn't just clean things any more, but they left behind a residue that killed the bugs even after we had finished cleaning.

These compounds – *chlorophenols*, and in particular *Triclosan* – were developed to disinfect hospitals. But then, due to certain people's paranoia about dirt, they escaped, making their way into, not surprisingly, cleaning fluids. Then, into other cleaning products like toothpaste, mouthwash. Finally, they have been incorporated into plastics and polymers, and even the clothes we wear and the work surfaces that we eat from, to make us all cleaner.

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But have we been sold a dud? It looks that way. Compounds like Triclosan produce harmful pollutants when they breakdown. But more than that, they may also be harming our immune system, and breeding a strain of anti-biotic resistant super-bugs.

What is Triclosan?

Triclosan was invented to clean hospitals. It is manufactured by the large pharmaceutical companies like Ciba Geigy. As a chlorophenol, it's related to many other highly toxic compounds. But the action of Triclosan on simple organisms like bacteria, fungi and algae is very subtle. Triclosan doesn't directly break-down bacteria like bleach – bleach attacks any and all organic matter, disrupting its structure and killing it. Instead it targets the reproduction of certain compounds in the cell walls of bacteria so that they fall apart.

Triclosan was first developed as part of research into chlorophenols in the 1960s. Examples of other chlorophenols include the herbicides *2,4-D* and *2,4,5-T*, which along with the compound *hexachlorophenol* formed the major components of the chemical *Agent Orange* that was used as a defoliant in the Vietnam War and which still poisons many Vietnamese people today.

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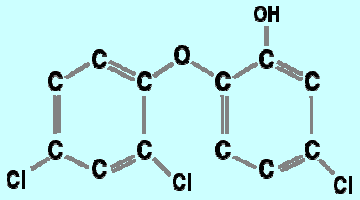
The use of Triclosan outside of hospitals has taken place for purely 'cosmetic' reasons. It is promoted as a compound that makes the environment of the home safe from germs. But in Danish Environmental Protection Agency reports, it is stated that there is no good reason to use Triclosan in any household products[1].

The chemical structure of Triclosan (see the 'Chemistry of Triclosan' box on the next page) is very similar to another group of compounds – *polychlorodibenzodioxins*. It has been found that the ultraviolet component of sunlight causes Triclosan to break-down into *2,8-dichlorodibenzodioxin*. This can happen when Triclosan is present on a cleaned surface, or on any article containing or impregnated with Triclosan. The limiting factor on this reaction is that the pH of the media that the Triclosan is present within must be great than 8.0[2]. But cleaning solutions, and the pH of many rivers and lakes, is such that Triclosan can be easily converted to dioxin in the environment. If other sources of chlorine radicals are present at the same time – for example the chlorination of water in water treatment work – then it is possible that Triclosan could provide the precursor for the more highly chlorinated, and so more toxic, chlorophenol and dioxin compounds.

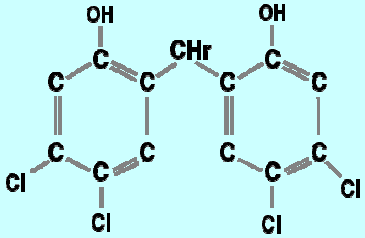
The Chemistry of Triclosan

Triclosan is one of a group of compounds called chlorophenols. These compounds are toxic to varying extents. Triclosan, or *2,4,4'-trichloro-2'-hydroxydiphenyl ether*, kills bacteria by inhibiting certain cellular functions. It has a low toxicity to human physiology. But other chlorophenol compounds are directly toxic to humans and other life forms.

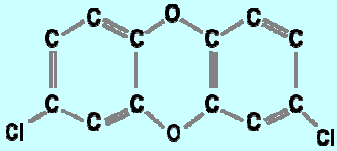
The chemical structure of Triclosan (see right) is based upon two benzene rings, each made up of six bonded carbon (C) atoms. There are many other chemicals based upon this structure. What distinguished them is the arrangement of other elements around the edge of the benzene rings. Changing the position of an element on the ring creates a new compound with a very different chemical effect and toxicity.



Chlorophenol compounds are widely used as pesticides and herbicides, or as wood treatments like pentachlorophenol. Many of these compounds have been banned recently because of concerns about their environmental toxicity. The major difference between the chlorophenols is the positioning of chlorine (Cl) atoms on the benzene rings. For example, the compound hexachlorophenol is also a bactericide. The difference in its structure (see left) can be seen by the addition of more chlorine atoms and a hydroxyl (OH) group.



Some of the most toxic compounds known to science are the dioxins. These are related to the chlorophenols. The more chlorine atoms attached to the rings, the more toxic these compounds become. When Triclosan degrades in ultraviolet light it produces 2,8-dichlorodibenzodioxin – or 2,8-DCDD (see right). This is one of the lesser toxic dioxin (about 15,000 times less toxic than the worst of the dioxins, 2,3,7,8-tetrachlorodibenzodioxin – 2,3,7,8-TCDD).



The production of Triclosan also produces a wide range of trace chlorophenols, including dioxins, as contaminants. These compounds cannot be avoided due to the impurities that are always produced within the production of chloro-carbon compounds. Therefore Triclosan itself can present a small risk to health because of the possible presence of other highly toxic chlorophenols. The presence of these compounds in waste materials, such as municipal waste or sewage sludge, also means that they can act as a precursor for the formation of the more toxic chlorophenols or dioxins in the environment.

Triclosan and anti-biotic resistant super-bugs

Triclosan inhibits the action of genes in the bacteria that process the fatty acids in its cell walls[3]. This is why Triclosan is toxic to bacteria. But the fact that Triclosan works at the genetic level, rather than being an out-right biocide like bleach, means that the potential exists for bacteria to evolve a resistance to the use of Triclosan[4].

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There are great concerns about antibiotic resistance – caused by the over-use of antibiotics in agriculture and by the over-prescription of antibiotics for humans. Infections produced by bacteria, like *Escherichia* and *Staphylococcus*, are becoming harder to treat because they are resistant to a wider range of antibiotics. For example the hospital super-bug *MRSA* (multiply resistant *Staphylococcus aureus*) can only be treated with most potent of antibiotics. The best way of avoiding MRSA is to improve the cleanliness of hospitals. But if the bacteria that people bring into the hospital have become immune to the use of disinfectants like Triclosan, because of the widespread use of Triclosan in society, then hospital super-bugs like MRSA will become more pervasive.

Studies from the USA and Norway[5] have shown that Triclosan is making its way into the sewage system, and from there into the environment. This means that it could be having a serious impact on the environment through chemical reactions producing other toxic chlorophenols and dioxins. But the fact that Triclosan is so widely distributed means that it is far more likely to come into contact with a wide range of bacteria. From there, it is just a matter of population dynamics. The action of Triclosan removing the susceptible bacteria, and leaving the resistant bacteria, means that there are more resistant bacteria remaining in the environment to reproduce. So eventually, the dominant strain of bacteria will be the resistant bacteria – and then we have a problem.

The risk of Triclosan to the environment is laid out clearly in a study by the Danish Environmental Protection Agency[1]:

> *In ordinary households, the amendment of e.g. cleaning products with bactericidal substances like Triclosan is not necessary. Investigations have shown that there is no reason to believe that bactericidal cleaning products or cosmetics are more efficient than the usual products. However, the use of disinfectants is necessary in places where bacteria must not be present, e.g. swimming pools. For such purposes, it is important that the efficiency of the products is not reduced due to resistance in the target bacteria.*

Bactericidal substances may also be slowly degradable in waste water treatment plants and in the environment where, in addition, they may cause adverse effects as these substances were developed to be toxic to living organisms (bacteria). Furthermore, potential discharge of sewage containing bactericides with long retention times in the environment may enhance the risk of developing resistance.

To plagiarise Nietzsche, "*what does not kill them makes them stronger*". This succinctly sums up bacterial resistance. And the over-use of Triclosan, and other such anti-bacterial agents, could eventually nullify the purpose of their use.

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"Dirt is good for you"

Is was assumed that any agent that harmed human physiology must be bad, and therefore must be extinguished from our lives. But as human civilisation has become cleaner we have begun to evolve a whole new range of illnesses – allergies, and other chronic autoimmune diseases. This idea that we live in an environment that is *too* clean is called the *hygiene hypothesis*[6] (see box above).

So why then do we try and make our homes cleaner still using anti-bacterial products? Rather like the previous Free Range Briefing (03/03) on *Teflon*, the prompt for the writing of this briefing was the fact that even the clothes we buy in shops are being coated in anti-bacterial agents like Triclosan. There is no scientific or public health reason to support this. Just the opposite. It could be argued that anti-bacterial agents, irrespective of the issues of what they break-down into or whether they cause bacterial resistance, pose a greater hazard to our health by removing crucial developmental stimulae for our immune systems.

In Douglas Adam's, *Hitch-hikers Guide to the Galaxy*, the rulers of the planet Golgafrincham removed the 'useless' third of their society, like telephone sanitisers, by sending them off in a space ship. The remaining population then died of a virulent disease contracted from a dirty telephone. Perhaps Triclosan, by either toxicity, bacterial resistance, or by stifling the development of our immune systems, will provide a similar service for modern human society – but this time because the phone was too clean.

The 'Hygiene Hypothesis'

There are various reasons why there are more autoimmune disorders in modern society. But one key factor appears to be the lower level of infections in children before their fifth birthday[7].

When you remove the stimulation to the immune system provided by these infections, the immune system does not develop properly. What is worse, immunisation programs provide the wrong type of stimulation to the immune system, possibly provoking autoimmune disorders as a response[8].

Autoimmunity – where the body's immune system attacks itself – appears to be a by-product of this lack of stimulation. The immune system may deal with a lack of stimulation by responding to certain proteins in food, creating allergies to certain food types, or reacting to proteins from the environment, such as house dust or pets, creating allergies like asthma or rhinitis. But the immune system may also target certain proteins within the body itself, causing a wide variety of illnesses such as diabetes, rheumatoid arthritis and lupus.

As yet the hygiene hypothesis is still just a hypothesis – it has not been proven. But it provides a powerful argument why, when our cities and our food have never been cleaner, we are seeing an increase in reported illnesses amongst the populations of the developed world.

Sources:

1. *Fate and Effects of Triclosan*, Lise Samsøe-Petersen, Margrethe Winther-Nielsen and Torben Madsen, Danish Environmental Protection Agency, 2003.
2. *Photochemical fate of pharmaceutical compounds discharged and detected in natural waters*, W.A. Arnold, K. McNeill, J.L. Packer, D.E. Latch, and A.L. Boreen, University of Minnesota, 2003
3. *Triclosan targets lipid synthesis*, Laura M. McMurry, Margret Oethinger, and Stuart B. Levy, Center for Adaptation Genetics and Drug Resistance, and Department of Molecular Biology and Microbiology, Tufts University School of Medicine – published in *Nature* 3941, 6th August 1998.
4. *Broad spectrum antimicrobial biocides target the FabI component of fatty acid synthesis*, Heath, R.J., Y.T. Yu, M.A. Shapiro, E. Olson, C.O. Rock – published in the *Journal of Biological Chemistry* 273(46):30316-20 [1998].
5. *Analyse av triklosan i kosmetiske produkter*, Anne Mette Eide, Næringsmiddeltilsynet (Norwegian Research Council), June 2003.
6. For example, see *Salon's* two part feature, T*alking Dirty* – www.salon.com/health/feature/2000/05/03/germ_warfare/ www.salon.com/health/feature/2000/05/04/germ_warfare_two
7. *Archives of Disease in Childhood*, vol 77, p 384.
8. *Let Them Eat Dirt*, Garry Hamilton, *New Scientist*, July 18 1998

The Free Range Network is a 'disorganisation' of activists and specialists that organises workshops and develops information resources for community and grass roots campaigning organisations. Free Range Bulletins are produced on an occasional basis, and are intended to promote debate and learning on current campaign issues.