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## A Review on “Triclosan A Controversial Antibacterial”

			
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### ABSTRACT

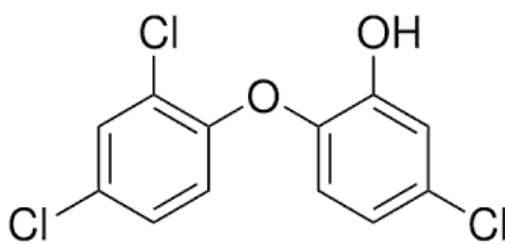
The chemical, Triclosan is a synthetic, broad-spectrum antimicrobial agent that has exploded onto the consumer market in wide variety of antibacterial soaps, deodorants, toothpastes, cosmetics, fabrics plastics and other products. They belong to the class of chemicals suspected of causing cancer. Studies linked with Triclosan have shown various adverse effects related to health as well as on environment, ranging from skin irritation, allergic vulnerability, bacterial and compounded antimicrobial resistant, and dioxin contamination to destruction of fragile aquatic ecosystems. Certain pharmaceuticals, as well as personal care products that are incorporated into this type of antibacterial substance, promotes good health is misleading. Prolong domestic use of such a very strong antimicrobial agent causes more harm than benefits. Many antimicrobial treatments are toxic detrimental method to eradicate all microorganisms to which they are applied. This approach includes the risk of toxicity to host organisms, (including humans) exposed to treatment for microbial infections. Constant exposure to Triclosan may cause genetic mutations of microbes and result information of harmful microbes that are more resistant. Besides its medical purposes, Triclosan is incorporated as an antimicrobial pesticide in conveyor belts, fire hoses, dye bath vats, or ice-making equipment etc. After performing a wide analysis on Triclosan, serious side effects has been observed and therefore it is wiser to limit the use of compounds that are incorporated into the same, except when prescribed or when there is infection or disease.

## INTRODUCTION:

Triclosan is an antibacterial agent (kills or slows down the growth of bacteria), and at the same time, it possesses some antifungal and antiviral properties. They are commonly used to kill bacteria on the skin and other surfaces. It is widely used in products to prevent deterioration due to microbes. Its use began in the US in the 1970s in soaps, and its uses have risen dramatically in the past few years including deodorants, cosmetics, cleansing lotions, toothpaste, plastics and fabrics.

Triclosan is a phenyl ether, or chlorinated bisphenol, with a broad-spectrum antimicrobial action which is classified as a Class III drug according to the BCS system (Class III drugs are compounds with high solubility and low permeability).

Chemical formula:  $C_{12}H_7Cl_3O_2$



**Figure 1: Structure of Triclosan**

This organic compound is a white powdered solid with a slightly aromatic, phenolic odor. Categorized as a polychloro phenoxy phenol, Triclosan is a chlorinated aromatic compound that has functional groups representative of both ethers and phenols. The presence of phenols gives its antibacterial properties. It is soluble in ethanol, methanol, diethyl ether, and strongly basic solutions such as a 1M sodium hydroxide solution, but only slightly soluble in water. Triclosan can be synthesized from 2, 4-dichlorophenol.

## Mechanism of action:

Depending upon their level of concentrations, Triclosan acts as both biocide and bacteriostatic. It targets bacteria primarily by inhibiting fatty acid synthesis.

Triclosan attach to bacterial enoyl-acyl carrier protein reductase (ENR) enzyme, which is encoded by the gene *FabI*. This binding increases the enzyme's affinity for nicotinamide adenine dinucleotide ( $NAD^+$ ) that results in the formation of a stable, ternary complex of

ENR-NAD<sup>+</sup>-Triclosan, which is unable to take part in fatty acid synthesis. Fatty acids are required for building and reproducing cell membranes.

### **Major Concerns related by the use of Triclosan:**

#### **Body load**

Triclosan exposure has resulted in higher levels of the chemical in body. It has been found in blood, urine and breast milk of people across the globe. It has also, shown up in consumers who do not use Triclosan and it is expected that they are exposed to it through food, water, and even household dust.

A study conducted in Australians confirms that the 31-45 year old age group had the highest levels of Triclosan in the blood.

#### **Health hazards**

Some data shows that Triclosan and similar antimicrobials affect the central nervous system, are linked to increased allergies and asthma, may promote bacterial resistance, cause environmental damage, may degrade into dioxin, and in many cases are no more active against germs than usual soap and water.

There have been reports of contact dermatitis, or skin irritation, from exposure to Triclosan. There is also evidence that Triclosan may cause photoallergic contact dermatitis (PACD) such as eczematous rash, which occurs when the part of the skin exposed to Triclosan is also exposed to sunlight. Triclosan has also been associated with a higher risk of food allergy. This may be because exposure to bacteria reduces allergies, as predicted by the hygiene hypothesis and not toxicology of the Triclosan itself. This would also occur with chlorhexidine gluconate and PCMX, among other antibacterial agents. Other studies have linked Triclosan concentrations have been associated with allergic sensitization, especially inhalant and seasonal allergens, rather than food allergens.

A number of recent studies lead to concerns that Triclosan is an endocrine disruptor. The laboratory studies, on rats and frogs, demonstrate that Triclosan can disrupt thyroid hormone. Its exposure may also disrupt thyroid hormone-associated gene expression. A study by British researchers found that Triclosan has estrogenic and androgenic hormone properties, and exposure could potentially contribute to the development of breast cancer.

Researchers at UC Davis found that Triclosan elevates calcium levels in cells, which can potentially affect neurodevelopment and neurological function. Triclosan has also been shown to impair mitochondrial function in mammalian cells.

### **Antibiotic Resistance of Triclosan**

Triclosan may induce antibiotic resistance in pathogenic bacteria. Scientists worldwide are concerned that the overuse and misuse of antibiotics and antimicrobials may lead to an increased resistance among bacteria.

Triclosan is fat-soluble and easily penetrates the bacterial cell wall. And once inside the cell it charges an enzyme that is used to produce fatty acids that are vital to cell function. This type of mode-of-action could finally lead to the development of antimicrobial resistance. Through unlimited use of Triclosan, non-resistant bacterial strains would be killed, leaving only the bacteria whose enzyme system has gained an ability to resist the presence of Triclosan. Some microbiologists, as well as health care professionals, fear that the commercial and personal overuse of Triclosan could reduce efficacy of currently useful antibiotics.

According to the assessments of the Norwegian Scientific Committee for Food Safety, experts concluded that “Prevalent use of Triclosan, including use in beauty aids, results in the development of Triclosan resistance. Since this may contribute to the development and spread of concomitant resistance to clinically important antimicrobial agents, such use represents a public health risk. Therefore, the use of Triclosan should be restricted.”

### **Impacts to ecosystem**

Triclosan is toxic to algae, phytoplankton, and other aquatic life. Since they inhibit fatty acid synthesis in bacteria, and because bacteria and plants have similar fatty acid biosynthesis pathways, Triclosan may also have inhibitory effects on plants. Triclosan has also been shown to have genotoxic and cytotoxic effects in algae. Triclosan is lipophilic in nature, and thus it has been found to bioaccumulate in earthworms, algae, and other organisms. Researchers are concerned that it will accumulate and spread through aquatic and terrestrial food webs.

Triclosan has also been found to have additive and even synergistic effects when combined with other common contaminants of waterways, potentially making Triclosan more toxic.

One study found that a mixture of low environmentally relevant concentrations of commonly used antibacterial agents significantly inhibits algal growth, including a level of Triclosan that is well below the concentration that produced no observed effect.

In addition, some research suggests that Triclosan bioaccumulates in fish tissue. According to a literature review by the Danish Environmental Protection Agency, Triclosan bioaccumulates in fish, with bioaccumulation factors of 3,700 to 8,400. This means that the concentrations found in fish are thousands of times higher than what is found in the water column.

Furthermore, at least one transformation product, methyl Triclosan, is relatively stable in the environment, thus it is available for bioaccumulation. Once methylated, the lipophilicity of Triclosan increases, meaning that it will be more likely to bioaccumulate in fatty tissue and is not likely to photodegrade. In a Swiss study, the lipid-based concentrations of methyl Triclosan observed in fish were considerably higher than the concentrations in lake water, suggesting significant bioaccumulation of the compound. For aquatic organisms, the potential uptake mechanisms of lipophilic contaminants are direct uptake from water through exposed surfaces, mainly gills (bio-concentration), and uptake through the consumption of food (bio-magnification).



### **Environmental Fate of Triclosan**

Triclosan has been found in both surface water and wastewater. Surface water sources may include wastewater treatment plant effluent, urban storm water, rural storm water, and agricultural runoff.

The transport of Triclosan to wastewater treatment plants occurs when people:

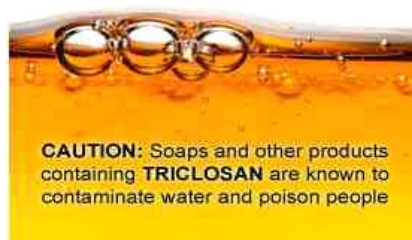
- Wash hands with antibacterial soap
- Hand wash dishes with antibacterial soap
- Clean with antibacterial products
- Use antibacterial products in a dishwasher
- Bath or shower with antibacterial soap or shampoo

- Brush teeth with toothpaste containing antibacterial products
- Wash clothes with antibacterial products
- Wash antibacterial cutting boards

Products that contain Triclosan wash down our drains and into water systems and waterways, where Triclosan has become a common contaminant. Sewer overflows and wastewater effluent deposits both contribute to Triclosan contamination of waterways. Triclosan accumulates in sewage sludge from municipal wastewater treatments and it is the major source of Triclosan in waterways. The sewage sludge is spread on land and Triclosan leaches down through the soil and runs off into surface water from the fields. Concentrations of Triclosan in runoff have been found to be at levels above what was shown to alter thyroid-mediated gene expression and development in frogs. Triclosan was detected in runoff from treated fields as long as 266 days after the biosolids application.

Triclosan has also been shown to persist in sediment for long periods of time. One study of sediment cores near wastewater treatment plants led the authors to state, “Triclosan concentrations in sediments show no significant evidence of degradation within the first few years after deposition.”

Unfortunately, Triclosan also persists in the home. A 2007 study looking at indoor dust samples found Triclosan present in all samples of dust from private homes, and in surprisingly large amounts. The average value (702 ng/g) was not far from the micro-gram per gram range, which is the typical level reported for this compound in sludge.



**Figure 2: Caution for Triclosan containing products**

## Breakdown Products

When Triclosan is released into the environment, the compound may undergo photodegradation or biodegradation. Several studies have shown that Triclosan can be transformed into other potentially toxic compounds, including methyl Triclosan, dioxins, chloroform, and other chlorinated compounds. Triclosan is likely being methylated in wastewater treatment plants, where there is a high density of microorganisms. Both Triclosan and its transformation product (methyl Triclosan) are found in wastewater treatment plants effluent.

- **2, 8-Dichlorodibenzo-*p*-dioxin (2, 8-DCDD):** a type of dioxin. Researchers in the UK and Japan found that close to 1 percent of Triclosan is converted to 2, 8-DCDD when photodegraded and that the 2, 8-DCDD actually persists longer than Triclosan. 2, 8-DCDD was also found to be a toxic intermediate product when Triclosan degrades in surface waters, on fiber coatings, and in real contaminated wastewater samples.

- **2, 4-Dichlorophenol (2,4-DCP):** an endocrine disruptor and a U.S. EPA priority pollutant. Detected by researchers in Spain and Cuba studying the degradation of Triclosan in the presence of low levels of chlorine. Confirmed in studies by researchers at Virginia Polytechnic and University of Minnesota. Also confirmed in real wastewater samples.

- **2, 4, 6-trichlorophenol (2, 4, 6-TCP):** an endocrine disruptor. Detected by researchers in Spain and Cuba studying the degradation of Triclosan in the presence of low levels of chlorine.<sup>39</sup> Confirmed in studies by researchers at Virginia Polytechnic.

- **Chloroform:** a carcinogen. Researchers at Virginia Polytechnic found that chloroform is created when Triclosan reacts with free chlorine in tap water, and that, in some circumstances, it occurs in levels above the U.S. EPA Maximum Contaminant Levels for chloroform in drinking water. The researchers stated, "...The potential exists for substantial chloroform production to occur via daily household use of Triclosan containing products."

- **Methyl Triclosan:** a metabolite of Triclosan. Bioaccumulates in algae and grass shrimp and has been found to be more bioaccumulative than Triclosan. One study concluded, Triclosan and methyl Triclosan have been identified as two of the major pollutants that currently contribute to the acute toxicity of domestic wastewater."



### Regulations for Triclosan Use:

Antimicrobial pesticides, such as Triclosan, are used to inhibit the growth of micro-organisms and are regulated by the EPA. When they are included in products which are intended for contact with the human body such as cosmetics or in food or food wrappers, it is not considered as a “pesticide” according to U.S law and it is regulated by FDA.

•**Deodorants:** Antiperspirant deodorant spray having 0.25% Triclosan reduced bacterial counts per cm<sup>2</sup> of skin from  $5.2 \times 10^5$  to  $1.4 \times 10^3$  and  $3.74 \times 10^2$ , respectively.

•**Soaps:** A study revealed that the efficacy of Triclosan does not reduce the bacterial counts on hands unless if it is used repeatedly in relatively high concentrations.

•**Plastics:** Triclosan - incorporated plastics do not release sufficient amounts of Triclosan to inhibit bacterial growth.

Products that containing Triclosan when used by a consumer may result in its absorption in small amounts through skin or the mouth.

Incorporation of Triclosan in different products does not have a proven benefit. Their wide application has resulted in the promotion of growth of many antibiotic resistant bacteria's. Thus it is major concern among many health promoters as well.

Products with Triclosan must be included it on the label.



Figure 3: Label for Triclosan containing product



### **Precautions of Triclosan:**

Triclosan is not presently considered as hazardous to humans. But several scientific research has come out since the last time FDA reviewed this ingredient that merits further review. On the basis of these studies, FDA is engaged in an ongoing scientific and regulatory review of this ingredient.

### **Some safety considerations include:**

- If you want to avoid products with Triclosan, go through the list of ingredients printed on the label.
- Read and follow the instructions given. Especially products such as mouthwashes and toothpaste, to avoid its swallowing.
- Health representatives and pharmacists should know about safe handling practices of Triclosan containing products. They should also be capable of counseling the people regarding its safe use.



### **DISCUSSION:**

Triclosan is an antimicrobial chemical used in a wide range of consumer products, including soaps, deodorants, cosmetics, cleansing lotions, toothpaste, plastics, fabrics etc. As we have gone through their demerits earlier, it is stated that the harmful effects of Triclosan is threefold: in our bodies, our environment and in the way that it contributes to antibiotic resistance.

The detrimental effects of Triclosan begin at the skin, with reports of contact dermatitis after exposure; there is also evidence that Triclosan may cause photoallergic contact dermatitis that may trigger an eczematous rash on the face, neck, the back of the hands and arms. As the chemical is lipophilic it is easily absorbed into our bloodstreams, which is then stored in fat cells. Further exposure of the same may result in concentration build-up in our body. Studies have suggested that high levels of Triclosan in blood may lead to central nervous system depression and impaired thyroid function, as well as hormone disruption. It is understood that Triclosan has not been linked directly to cancer; the manufacturing process for Triclosan may lead to the production of carcinogenic dioxins. Triclosan on exposure with chlorinated water

or UV light produces a specific type of dioxin which is particularly carcinogenic, and this may more often occur when using the public water supply.

Allergic problems may also likely to occur with Triclosan. Nowadays marketing strategy on cleansing and other related products is completely based on excessive cleanliness. According to the British doctor David Stracham, problems like allergies, asthma, hayfever and eczema are caused by an immature immune system. Our immune system function better by sampling the environment for small doses of potentially harmful substances such as bacteria, fungi, viruses, then developing antibodies to repel them off. High state of sanitation reduces the chance of all exposure to potential pathogens, and therefore our immune systems have no way to practice and instead turn on our own bodies. Once a stimulus finally does arrive, the unprepared body overreacts and produces a huge response to tiny inputs. Recent studies have even shown that children accompanied pets or other farm animals are far less likely to develop asthma, allergies, etc. than their deprived counterparts.

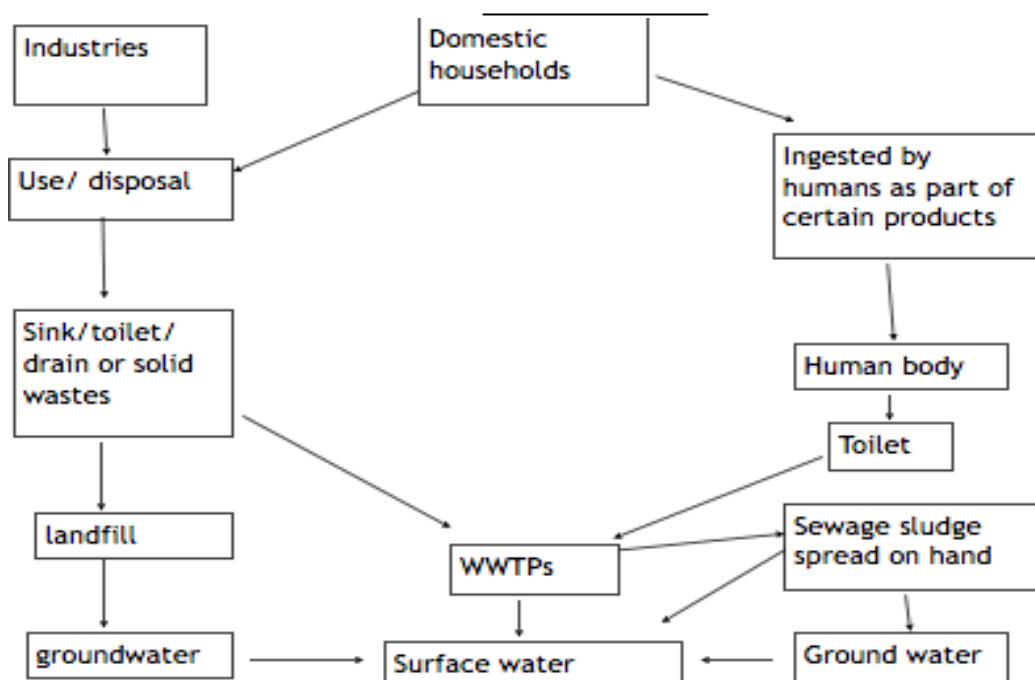
The second issue with Triclosan is environmental. Almost 95% of the products which contain Triclosan finally washed down the drain, eventually finding their way to our waterways and public water supplies. Water treatment plants don't remove Triclosan. Thirty-year-old sediment on river floors has turned up traces of Triclosan, indicating that the chemical has underwater longevity. Triclosan is highly harmful to some types of algae and phytoplankton, which form the base of the aquatic food chain and harmful to Japanese medaka fish. It also accelerates the rate at which tadpoles grow into frogs. It has been found in the blood of variety of marine species, especially on bottlenose dolphins. Since this chemical is a major contaminant in sewage sludge that is often spread on land, now shows up in earthworms. The duration of Triclosan in personal product use is relatively short.

#### **Environmental Hazard:**

- Disposal, Triclosan is sent to municipal sewage treatment plants, where about 97-98% of Triclosan is removed.
- The effluent from wastewater treatment facilities, approximately 75% of Triclosan was present in sludge.
- Potential environmental and ecological hazard particularly for aquatic systems.

- Ozone is considered to be an effective tool for removing Triclosan during sewage treatment.
- As little Triclosan is released through plastic and textile household consumer products, these are not considered to be major sources of Triclosan contamination.
- During wastewater treatment, a portion of Triclosan is degraded, while the remaining adsorbs to sewage sludge or exits the plant as effluent.
- In the environment, Triclosan may be degraded by microorganisms or react with sunlight, forming other compounds, which include chlorophenols and dioxins.
- The environmental concentrations of Triclosan may affect bacterial activities. Consequently, it is important to evaluate the fate of Triclosan in the environment such as in WWTPs, rivers, effluents, etc.
- Aerobic bacterial hydrolysis plays an important role in Triclosan degradation.
- Triclosan can have detrimental effects on aquatic ecosystems.
- Effluents affect both the structure and function of algal communities in stream ecosystems.
- The amount of Triclosan that is released into the environment can affect plants and animals in lakes, streams, and rivers.

Different environmental compartments namely, air, water and soil. The possible pathways for releases of Triclosan to diagram proposed by bound and voolvoulis (2005) for pharmaceuticals in the environment.



**Figure 4: possible pathways for releases of Triclosan**

The presence of environmental hazard in the human body does not necessarily imply that they are causing adverse health effects; however, environmental chemical exposures can do affect human health. The overuse of Triclosan (and other antibacterial chemicals) may also be linked to increased allergies and asthma.

The third problem with Triclosan is its contribution to the rise of superbugs. Laboratory studies have revealed that a number of different strains of mutated bacteria are resistant to the chemical. These studies found that these mutant strains of bacteria also showed resistance to certain antibiotics. While most resistant bacteria grow more slowly than sensitive bacteria, E. coli strains that are resistant to Triclosan actually have increased growth rates. In a recent review of the subject, one researcher concluded, “It is therefore quite possible that widespread use of Triclosan may indeed compound antibiotic resistance.”

#### **Health Hazard:**

- A number of recent studies lead to concerns that Triclosan is an endocrine disruptor.
- Exposure to Triclosan also disrupts thyroid hormone-associated gene expression.
- Triclosan has also been shown to impair mitochondrial function in mammalian cells.

- Contact dermatitis, or skin irritation and an increase in allergic reactions, especially in children.
- Breathing in large quantities of dust generated during occupational use of Triclosan powder can cause health effects in workers.
- Skin products containing Triclosan rarely have caused irritation.
- Exposed to individual human muscle cells (from heart and skeletal muscles) to a Triclosan dose similar to everyday life exposure, and this too disrupted muscle function and caused both heart and skeletal muscles to fail.
- Damage by interfering with the constitutive and rostate receptor, a protein responsible for detoxifying (clearing away) foreign chemicals in the body.
- Children in the highest category of Triclosan exposure had double the risk of being allergic to common allergens.
- Increased susceptibility to tumor formation through enhanced cell growth, liver fibrosis (excessive accumulation of proteins in the liver) and pro-inflammatory responses, which are circumstances within human cancer forms.

#### **Advantages of Triclosan:**

- Triclosan is a very potent inhibitor, and only a small amount is needed for powerful antibacterial action.
- Triclosan has had an important role in hospitals where dangerous bacteria are common and there are many susceptible patients.
- Highly effective at killing germs.
- Fight germs for extended period of time.
- It can relieve inflamed skin.

#### **Disadvantages of Triclosan:**

- Rash and dermatitis.

- Disrupts thyroid hormone.
- Depressant effect
- Fat soluble
- Tadpole premature metamorphosis

**List of products that contain Triclosan:**

**SOAP:** Dial Liquid Soap; Softsoap Antibacterial Liquid Hand Soap; Tea Tree Therapy Liquid Soap; Provon Soap; Clearasil Daily Face Wash; Dermatologic Skin Purifying Wipes; Clean & Clear Oil Free Foaming Facial Cleanser; DermaKleen Antibacterial Lotion Soap; Naturade Aloe Vera 80 Antibacterial Soap; CVS Antibacterial Soap, pHisoderm Antibacterial Skin Cleanser, Dawn Complete Antibacterial Dish Liquid, Ajax Antibacterial Dish Liquid.

**DENTAL CARE:** Colgate Total; Breeze Triclosan Mouthwash; Reach Antibacterial Toothbrush; Janina Diamond Whitening Toothpaste.

**COSMETICS:** Supre Café Bronzer; Total Skin Care Makeup Kit; Garden Botanika Powder Foundation; Mavala Lip Base; Jason Natural Cosmetics; Blemish Cover Stick; Movate Skin Lightening Cream HQ; Paul Mitchell Detangler Comb, Revlon ColorStay LipSHINE Lipcolor Plus Gloss, Dazzle.

**DEODORANT:** Old Spice High Endurance Stick Deodorant, Right Guard Sport Deodorant, Queen Helene Tea Tree Oil Deodorant and Aloe Deodorant; Nature De France Le Stick Natural Stick Deodorant; DeCleur Deodorant Stick; Epoch Deodorant with Citrisomes; X Air Maximum Strength Deodorant.

**PERSONAL PRODUCTS:** Gillette Complete Skin Care Multi Gel Aerosol Shave Gel; Murad Acne Complex Kit; Diabet-x Cream; T. Taio sponges and wipes, Aveeno Therapeutic Shave Gel.

**FIRST AID:** SyDERMA Skin Protectant plus First Aid Antiseptic; Solarcaine First Aid Medicated Spray; Nexcare First Aid, Skin Crack Care; First Aid/Burn Cream. HealWell Night Splint; 11-1X1: Universal Cervical Collar with Microban.

**KITCHENWARE:** Farberware Microban Steak knife Set and Cutting Boards; Franklin Machine Products FMP Ice Cream Scoop SZ 20 Microban; Hobart Semi-Automatic Slicer; Chix Food Service Wipes with Microban; Compact Web Foot Wet Mop Heads.

**COMPUTER EQUIPMENT:** Fellowes Cordless Microban Keyboard and Microban Mouse Pad.

**CLOTHES:** Teva Sandals; Merrell Shoes; Sabatier Chef's Apron; Dickies Socks; Biofresh socks.

**CHILDRENS TOYS:** Playskool: Stack 'n Scoop Whale, Rockin' Radio, Hourglass, Sounds Around Driver, Animal Sounds Phone, Busy Beads Pal, Pop 'n Spin Top, Lights 'n Surprise Laptop.



**OTHER:** Bionare Cool Mist Humidifier; Microban All Weather Reinforced Hose; Thomasville Furniture; Deciguard AB Ear Plugs; Bauer 5000 Helmet; Aquatic Whirlpools; Miller Paint Interior Paint; QVC Collapsible 40-Can Cooler; Holmes Foot Buddy Foot Warmer; Blue Mountain Wall Coverings; California Paints.; EHC AMRail Escalator Handrails; Dupont Air Filters; Durelle Carpet Cushions; Advanta One Laminate Floors; San Luis Blankets; J Cloth towels; JERMEX mops.

## **CONCLUSION:**

This study clearly revealed that antibacterial soaps containing Triclosan were no more effective than regular soap and water in fighting infection. Claiming that the products containing Triclosan promote good health is misleading. When used in hospitals and other health care settings, or for persons with weakened immune systems, Triclosan represents an important health care and sanitary tool. But outside of these settings, it is unnecessary and the constant exposure to Triclosan becomes a health and environmental hazard.



A number of health, as well as environmental hazards, were analyzed and the study revealed that constant exposure to these products may result in suppression of thyroid hormones, stimulate allergies and decrease the immune power. Certain metabolites of the chemical are carcinogenic and their increased concentration is highly toxic to the body.

Since Triclosan is found to produce toxic effect in the human beings, its presence should be left only in products where this compound actually brings some real benefits. This work was done to study the efficacy of Triclosan when used in such products or it may avoid the use of the same as antimicrobial agents in consumer products.

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