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MINI REVIEW

# Scrubbing with risk: health and environmental hazards of kitchen cleaning tools and sustainable alternatives

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**சுருக்கம்:**
ஸ்பொஞ்சுகளும் பாத்திரம் கழுவும் ஸ்க்ரப்புகளும், வீட்டிலும் வணிக சமையலறைகளிலும் பொதுவாக பயன்படுத்தப்படும் தூய்மை சாதனங்களாகும். எனினும், அவை தவறாக பயன்படுத்தப்படும்போது, கணிசமான ஆரோக்கிய மற்றும் சுற்றுச்சூழல் ஆபத்துகளை ஏற்படுத்தக்கூடும். இந்த குறு விமர்சன ஆய்வு, பண்டைய கிரேக்க மற்றும் ரோமக் கால சுத்தமுறைகளில் இருந்து இன்றைய நவீன செயற்கை மாற்றுகள் வரை ஸ்பொஞ்சுகளின் வரலாற்றுப் பயணத்தை அலசுகிறது. வழக்கமான ஸ்க்ரப்புகளுடன் தொடர்புடைய உடல் காயங்கள், வேதிப்பொருள் வெளியேற்றம் மற்றும் நோயிழைக்கும் நுண்ணுயிர் தொற்றுகள் போன்ற ஆரோக்கிய ஆபத்துகள் இதில் தெளிவாக விளக்கப்படுகின்றன. *ஈ.கோலை, சால்மொனெல்லா* மற்றும் *ஸ்டாபிலோகொக்கஸ்* போன்ற நுண்ணுயிரிகள் ஈரமாகவும் மீண்டும் பயன்படுத்தப்படும் ஸ்பொஞ்சுகளில் பெரும்பாலும் காணப்படுவதால், நோய்த் தொற்றுகளுக்கு வாய்ப்பு அதிகரிக்கிறது. சுற்றுச்சூழலுக்கான விளைவுகளும் இக்கட்டுரையில் விவாதிக்கப்படுகின்றன. செயற்கையாக தயாரிக்கப்படும் ஸ்பொஞ்சுகள் மற்றும் ஸ்க்ரப்புகள் மைக்ரோபிளாஸ்டிக் மாசுபாட்டை ஏற்படுத்துவதோடு, பெரும்பாலனவை அழியாத தன்மையுடையவையாக இருப்பதால், நீண்டகால சுற்றுச்சூழல் பாதிப்பை ஏற்படுத்தக்கூடியவையாக உள்ளன. இந்த விமர்சனம், இயற்கை நார் ஸ்க்ரப்புகள், சிலிக்கான் ஸ்பொஞ்சுகள் மற்றும் மைக்ரோவேவ் சானிடைசேஷன் போன்ற மேம்பட்ட சுகாதார நடைமுறைகள் உள்ளிட்ட பாதுகாப்பான மாற்றுத் தீர்வுகளை ஆய்வு செய்கிறது. மேலும், ஸ்பொஞ்சுகளை முறையிலான இடைவெளியில் மாற்றுவது மற்றும் சுத்தமாக பராமரிப்பது போன்ற நடைமுறைகள் நோய்த் தொற்றுகளைத் தவிர்க்க உதவும் என்பதை இது வலியுறுத்துகிறது. இந்தக் கட்டுரை, பாரம்பரிய பாத்திரக் கழுவும் உபகரணங்களுடன் தொடர்புடைய ஆபத்துகளைப் பற்றிய பொது விழிப்புணர்வை ஏற்படுத்தும் நோக்கத்துடன் எழுதப்பட்டுள்ளது. மேலும், ஆரோக்கியமான மற்றும் சுற்றுச்சூழலுக்கு உகந்த மாற்று வழிகளுக்கான ஆதரவை முன்வைக்கும் நோக்கத்தையும் கொண்டுள்ளது.

**Abstract:**
Sponges and vessel-washing scrubs are common cleaning implements in both domestic and commercial kitchens; however, they pose significant health and environmental hazards if misused. This mini-review examines the historical development of sponge use, from ancient Greek and Roman hygiene practices to modern synthetic substitutes. It highlights the health risks associated with conventional scrubs, including physical injuries, chemical leaching, and microbiological contamination. Organisms such as *Escherichia coli*, *Salmonella*, and *Staphylococcus* are often present on moist, repeatedly used sponges. Environmental concerns are also addressed, as synthetic cleansers contribute to microplastic contamination and are frequently non-biodegradable. The review further evaluates safer alternatives, including natural fiber scrubbers, silicone implements, and improved hygiene practices such as regular replacement and microwave sanitation. This article aims to raise public awareness about the hazards associated with conventional dishwashing products and to advocate for safer, more sustainable alternatives for better health and environmental conservation.

**Keywords:** kitchen sponges, microbial contamination, synthetic scrubs, eco-friendly alternatives, household hygiene



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## Introduction

A sponge is a cleaning implement composed of soft, porous material, primarily used for cleaning non-porous surfaces and particularly effective in absorbing water and aqueous solutions. Initially crafted from natural sea sponges, most are now manufactured from synthetic materials. The earliest references to sponges for cleanliness date back to Ancient Greece (1). Competitors in the Olympic Games anointed themselves with sea sponges saturated in olive oil or perfume prior to competition. In Homer's Odyssey, the deity Hephaestus cleanses his hands, face, and chest with a sea sponge, while attendants in Odysseus's palace use sea sponges to clean tables after meals. Greek philosophers Aristotle and Plato referenced marine sponges in both scientific and historical contexts. The ancient Greeks and Romans used sea sponges affixed to poles for anal hygiene, known as the xylospongium, which they cleansed with seawater (2). Ancient Romans also used sea sponges extensively for personal cleanliness and other purposes. The belief in the medicinal properties of sponges led to their use in healthcare for wound cleansing and illness treatment (3). The creation of synthetic sponges became feasible only with the development of polyester in the 1920s and the commercial production of polyurethane foam in 1952 (4). Vessel-cleaning scrubs are specialized implements used to remove dirt and food stains from cookware and dishes, and this is the routine in all households and commercial kitchens. Vessel-cleaning scrubs are available in various materials such as plastic mesh, nylon, steel wool, and other synthetic abrasives. Recent studies suggest that they have more potential health risks. The objective of this brief analysis is to investigate the risk associated with traditional vessel-cleaning scrubs and changes to propose safer and more environmentally friendly alternative materials (5).

## Composition of common vessel-washing scrubs

Commercially available scrubs are made from synthetic materials such as nylon mesh, polyurethane foam, or steel wool. These formulations use chemical coatings to increase cleaning efficacy or inhibit bacterial growth in the vessels. These materials are strong, but they aren't necessarily safe to touch food and may break down over time, releasing tiny pieces of plastic or metal. Sponges frequently have a rough surface that may scratch delicate kitchenware or skin (6). Vegetable cellulose, polyester, or polyurethane may be used to make synthetic sponges. Polyester sponges are frequently soft and yellow, which makes them good for cleaning dishes. They use polyurethane because it is rough. Kitchen sponges may let out tiny pieces of plastic and microplastics when they are used. People usually use wood-fiber vegetable cellulose sponges on their skin and in the bath. These sponges are usually more expensive and last longer than polyester sponges. They are better for the environment than synthetic sponges since they are manufactured from natural materials and break down in the environment (7). **Figure 1** illustrates common household cleaning sponges with dual-layer construction: the yellow foam provides absorbency and flexibility for general cleaning, while the green abrasive layer is designed for scrubbing tough stains and surfaces. This dual-function design is widely used in both domestic and commercial cleaning applications.

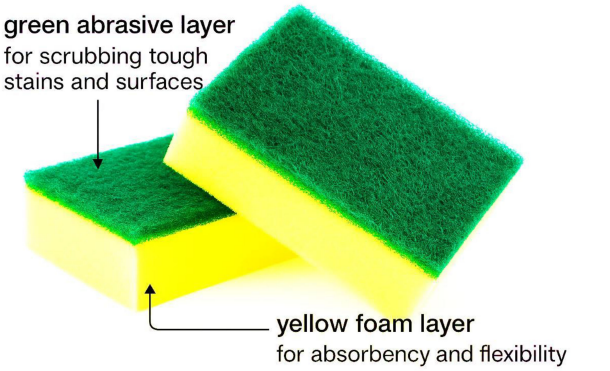


**FIGURE 1** | Vessel-cleaning scrubs commonly used in domestic cleaning.

When a sponge is left wet between uses, it can serve as a substrate for harmful bacteria or fungi. Studies have shown that some sponges may retain Salmonella for more than 7 days (8).

## Health hazards associated with scrub usage

### Physical risks

Abrasive scrubs can cause small cuts and skin abrasions, particularly with steel wool or hard plastic scrubbers. Frequent exposure may lead to contact dermatitis or irritation, especially in individuals with sensitive skin. Persistent friction can compromise the skin's barrier, resulting in irritation or disorders such as contact dermatitis. Hsieh and Tsai (9) note that recurrent mechanical irritation may lead to friction-induced dermatitis, manifesting as erythema, pruritus, and scaling. Individuals with sensitive skin should avoid abrasive cleaning tools and choose milder options to reduce the risk of skin harm. **Table 1** shows the physical risk of cleaning scrubs.

### Chemical risks

Chemical hazards can arise when using old or damaged kitchen scrubs, which may leave behind microplastics and

**TABLE 1** | Potential physical hazards linked to the everyday use of vessel scrubs.

| Physical risk | Description | Potential impact | Reference(s) |
|---|---|---|---|
| **Dermal abrasions** | Use of abrasive scrubbing materials may result in superficial skin injuries, including irritation and cuts. | Minor skin abrasions; increased risk of secondary infection if wounds are not properly managed. | (10) |
| **Musculoskeletal strain** | Repetitive or prolonged scrubbing motions can induce muscle fatigue or strain, particularly in the hands and forearms. | Acute discomfort and pain; potential development of chronic repetitive strain injuries (RSIs). | (11) |
| **Respiratory exposure to particulates** | Utilization of powdered abrasives or synthetic sponges may generate airborne particulates during cleaning. | Respiratory tract irritation; possible eye, nasal, and throat discomfort. | (12) |
| **Chemical dermatitis/burns** | Contact with harsh cleaning agents or prolonged exposure to chemical abrasives can cause skin burns or irritation. | Chemical burns; potential for chronic skin conditions or long-term tissue damage. | (13) |
| **Ocular injuries** | Splashes of cleaning agents or debris during scrubbing can enter the eyes. | Ocular irritation; risk of corneal injury or permanent vision impairment if untreated. | (14) |
| **Lacerations and puncture wounds** | Handling of scrub tools with sharp or rigid edges (e.g., metal brushes) may result in accidental cuts or punctures. | Lacerations or puncture wounds; increased risk of infection or tetanus if not addressed. | (15) |

chemical residues. For example, melamine sponges release microplastic fibres into the environment when worn down. Su et al. (16) found that these sponges release more than a trillion microplastic threads per month under normal use. Microplastics can adhere to surfaces and utensils, potentially leading to ingestion. Additionally, cleaning products may leave chemical residues that adhere to scrubbed surfaces. Sánchez et al. (17) observed that cooking and processing can facilitate the release of plastic ingredients such as phthalates and bisphenol A, which may then enter the bloodstream. It's crucial to think about the safety and quality of kitchen wipes to reduce chemical exposure and health hazards. **Table 2** makes it easy to grasp the chemical risks of scrubs.

## Microbial risks

The health and immunity of everyone in the home frequently rely on how clean the cleaning instruments are. Sponges that are used to clean dishes may be places where hazardous germs grow. People can think that infections caused by dirty sponges are foodborne illnesses. Researchers have shown that kitchen sponges may hold more germs than toilets, with up to 54 million bacteria per cubic centimeter. Bacteria may spread to vessels and other surfaces while they are being used, which can cause serious infections such as meningitis, pneumonia, fever, dysentery, and blood poisoning.

According to research by Osaili et al. (26), kitchen sponges used in student dorms included a lot of mesophilic aerobic bacteria, coliforms, *Enterobacteriaceae*, and yeasts/molds. *Enterobacter cloacae* (56%) and *Klebsiella oxytoca* (16%) were the *Enterobacteriaceae* that were most often found on their own. All of the *E. cloacae* isolates were resistant to more than one drug. Sponges and scrubs that retain moisture are breeding grounds for bacteria such as *E. coli, Salmonella, and Staphylococcus aureus*. Inadequate cleaning or prolonged use increases the risk of cross-contamination between dishes and surfaces. Marotta et al. (27) found significant microbial contamination in 100 used kitchen sponges, including aerobic mesophilic bacteria, *Enterobacteriaceae*, and yeasts/molds. Notably, 22.3% of enterobacterial strains tested positive for extended spectrum beta lactamase (ESBL), highlighting sponges as reservoirs for antibiotic-resistant pathogens. **Figure 2** shows microbial growth on kitchen scrubbers. This underscores the risk of foodborne illnesses from poor hygienic practices, as mentioned in the supportive images for microbial risk hazards.

The synthetic sponge exhibits very high contamination with various pathogenic bacteria, as indicated by red color-coded zones. The natural fiber sponge shows occasional environmental microbes and lower bacterial contamination (green), while the brush demonstrates minimal bacterial contamination due to less moisture retention. Color coding represents microbial load: red for high and green for low contamination.

Borrusso and Quinlan (28) found foodborne pathogens in 45% of Philadelphia homes, with contaminated sponges and cloths serving as strong indicators of wider surface contamination. **Table 3** shows the microbial hazards of the scrubs and microbes and their associated diseases.

## How to destroy the bacteria

Several methods can effectively clean sponges. Microwaving wet sponges for 2 minutes kills 99% of *coliforms*, *E. coli*, and MS2 phages, though *Bacillus cereus* spores require 4 minutes. It is critical to ensure sponges are wet before microwaving to prevent fire hazards. Dishwashers and soaking in dilute detergent solutions are also effective. Alternative cleaning

**TABLE 2 |** Potential chemical hazards arising from the use of kitchen vessel scrubs and their related effects on human health.

| Chemical agents | Source related to scrub use | Potential human health effects | Reference(s) |
|---|---|---|---|
| **Triclosan** | Incorporated as an antibacterial coating in scrubbing pads or present in soaps used with scrubs. | Endocrine system disruption, promotion of antibiotic resistance, dermatological irritation, and potential immune dysregulation. | (18) |
| **Bisphenol A (BPA)** | Found in plastic components of synthetic scrub sponges and kitchen utensils. | Hormonal imbalance, reproductive toxicity, carcinogenicity, metabolic disturbances, and gut microbiome dysbiosis. | (19) |
| **Phthalates** | Leaching from plastic handles of scrubs or storage containers. | Developmental and reproductive toxicity, endocrine disruption, asthma, and alterations to gut microbiota. | (20) |
| **Volatile Organic Compounds (VOCs)** | Chemical reactions between cleaning agents (e.g., bleach and ammonia) on sponges. | Respiratory tract irritation, neurological effects, and increased cancer risk. | (21) |
| **Per- and Polyfluoroalkyl Substances (PFAS)** | Present in non-stick or grease-repellent coatings on scrub pads. | Hepatotoxicity, thyroid dysfunction, immune suppression, and possible carcinogenicity. | (22) |
| **Chlorine (from bleach cleaners)** | Residual chlorine retained in sponges following disinfection. | Respiratory distress, mucosal membrane damage, and induction of reactive airway disease. | (23) |
| **Formaldehyde** | Component of polyurethane foam in synthetic sponges. | Carcinogenicity, skin and ocular irritation, and asthma exacerbation. | (24) |
| **Synthetic dyes (e.g., azo dyes)** | Employed in coloring the abrasive or foam layers of scrubs. | Allergic reactions, potential formation of carcinogenic breakdown products. | (25) |

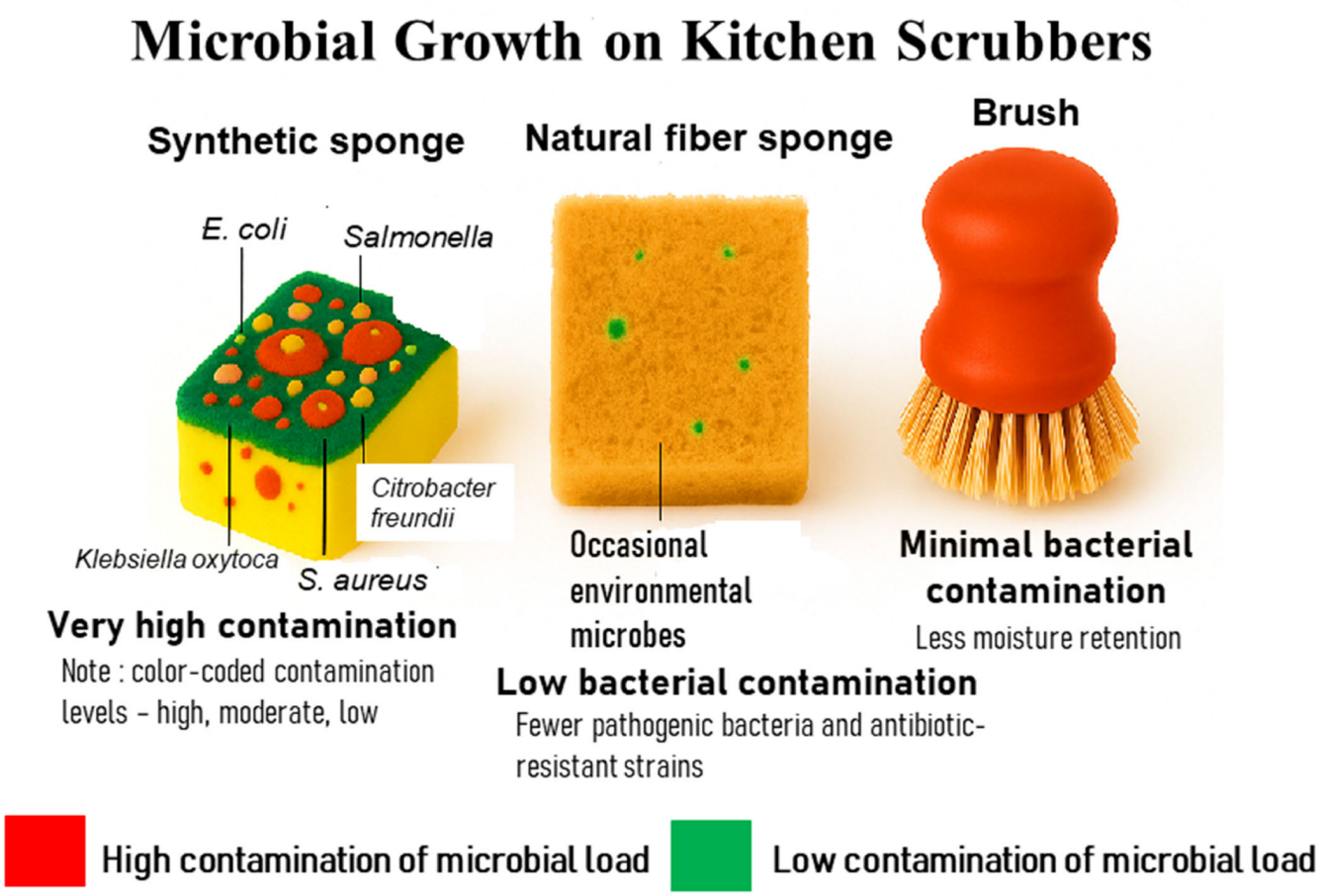


**FIGURE 2 |** Comparative analysis of microbial growth on different types of kitchen scrubbers.

**TABLE 3 |** Microbial hazards linked to prolonged use of vessel scrubs.

| Microorganisms | Type | Associated diseases | Reference(s) |
|---|---|---|---|
| *Escherichia coli* | Gram −ve bacteria | Gastroenteritis, urinary tract infections (UTIs), sepsis | (29) |
| *Salmonella spp.* | Gram −ve bacteria | Salmonellosis (diarrhea, fever, abdominal cramps) | (30) |
| *Klebsiella pneumoniae* | Gram −ve bacteria | Pneumonia, bloodstream infections, UTIs | (31, 32) |
| *Pseudomonas aeruginosa* | Gram −ve bacteria | Wound infections, respiratory tract infections, sepsis | (33) |
| *Staphylococcus aureus* | Gram +ve bacteria | Skin infections, methicillin-resistant *Staphylococcus aureus* (MRSA), food poisoning | (34) |
| *Enterococcus faecalis* | Gram +ve bacteria | Endocarditis, UTIs, intra-abdominal infections | (35) |
| *Campylobacter jejuni* | Gram −ve bacteria | Campylobacteriosis (diarrhea, fever, cramps) | (36) |
| *Acinetobacter baumannii* | Gram −ve bacteria | Pneumonia, bloodstream infections | (32) |
| *Moraxella osloensis* | Gram −ve bacteria | Opportunistic infections, bad odors from sponges | (37) |
| *Fungi* (e.g., *Candida spp.*) | Yeast | Oral thrush, candidiasis | (38) |

**TABLE 4 |** Safer uses of daily usage vessel-cleaning scrubs.

| Method | How to use | Effectiveness | Notes | Reference(s) |
|---|---|---|---|---|
| **Microwave heating** | Heat a damp sponge in the microwave for 1–2 minutes. | Kills >99% bacteria (including *E. coli* and *S. aureus*). | Ensure the sponge is wet to prevent fire; not suitable for sponges with metal. | (39) |
| **Dishwasher with heat dry** | Place sponge on top rack; run full cycle with heat drying. | Highly effective with >99% pathogen reduction. | Use regularly to prevent microbial regrowth. | (40) |
| **Bleach soaking** | Soak in a 1:10 bleach solution for 5–10 minutes, then rinse thoroughly. | Effective against most bacteria and viruses. | Use gloves and avoid inhaling fumes; not recommended for daily use. | (41) |
| **Vinegar or hydrogen peroxide soak** | Soak for 5–10 minutes. | Moderately effective for daily use. | Less harsh than bleach; can be used more frequently. | (42) |
| **Air-drying thoroughly** | Store sponge in a dry, ventilated area between uses. | Reduces bacterial regrowth by minimizing moisture. | Essential to prevent microbial persistence and odor. | (43) |
| **Regular replacement** | Replace sponge/scrub every 5–7 days in high-use settings. | Prevents biofilm formation. | Avoid long-term use even with disinfection. | (44) |

tools include scrub brushes, silicone brushes, metal scrubs, and dishwashers. **Table 4** explains clearly about clearing the microbes in the different possible ways and safer uses of daily scrub usage.

## Environmental concerns

The use of synthetic kitchen sponges contributes to environmental pollution through the release of microplastics. As these sponges degrade during regular cleaning, they shed microplastic and nanoplastic fibers that enter wastewater systems and accumulate in aquatic environments. These particles are not biodegradable, can harm marine life, and may enter the human food chain. Luo et al. (6) confirmed the release of such particles from kitchen sponges, highlighting their persistent nature and ecological impact. Reducing sponge use or switching to eco-friendly alternatives is essential.

## Material innovations

Natural fiber scrubbers, such as those made from coconut coir, loofah, and cellulose, are increasingly popular as eco-friendly alternatives to synthetic sponges. These materials are safe for skin and cookware and are biodegradable. Amutha and Ramya (45) demonstrated that natural fiber scrub pads made from cotton, sisal, coir, and banana bract were durable and suitable for kitchen cleaning, offering an effective alternative to non-biodegradable synthetic scrubbers. The study showed that these organic scrub pads could be used instead of manmade scrubbers that don't break down, which would be better for the earth. **Table 5** presents the prevention of physical, chemical, and biological hazards by the cleaning scrubs.

## Hygienic practices

To prevent the spread of harmful bacteria, it is essential to keep kitchen sponges clean. Research by Sharma and Mudd (53) found that microwaving a wet sponge for 1 minute killed 99.99999% of bacteria, while dishwashing achieved a 99.9998% reduction. However, due to rapid bacterial recolonization, frequent sanitization may not significantly reduce the bacterial load. Therefore, kitchen sponges should be replaced every week or two and thoroughly cleaned after

**TABLE 5 |** Prevention of physical, chemical, and biological hazards by the cleaning of vessels.

| Alternative materials | Benefits | Challenges | References |
|---|---|---|---|
| **Biodegradable detergents (e.g., Plant-based enzymes)** | Low toxicity—environmentally friendly—non-corrosive. | Limited cleaning power for heavy-duty applications. | (46) |
| **Electrolyzed water** | Non-toxic—effective against bacteria and biofilms—safe for workers. | Requires special equipment to produce electrolyzed water. | (47) |
| **Ultrasonic cleaning** | Uses high-frequency sound waves to remove debris—reduced physical contact, minimizing injury risks. | Requires specific equipment—potential for high energy consumption. | (48) |
| **Steam cleaning** | High-temperature steam kills bacteria and viruses—reduces chemical use. | High energy cost—requires equipment for steam generation. | (49) |
| **Plant-based scrubbing brushes** | Made from natural fibers—no chemical or biological contamination risks. | May be less effective on hard-to-clean surfaces. | (50) |
| **Microfiber cloths** | High absorption capacity—effective with minimal cleaning agents. | Limited use for heavy or sticky residues. | (51) |
| **Natural abrasive powders (e.g., baking soda, diatomaceous earth)** | Non-toxic—environmentally safe. | May be less effective on certain residues. | (52) |

**TABLE 6 |** Recommended alternatives for hygiene usage.

| Alternatives | Description | Benefits | Reference(s) |
|---|---|---|---|
| **Single-use disposable wipes** | Pre-sterilized or sanitizing wipes. | Eliminates reuse contamination; ideal for sensitive areas. | (54) |
| **Silicone scrubbers** | Non-porous, quick-drying materials. | Lower microbial retention; dishwasher-safe. | (5) |
| **Antimicrobial cloths (e.g., microfiber)** | Engineered to trap bacteria; some are infused with silver or copper. | Reusable; can be laundered; effective at removing debris. | (55, 56) |
| **Commercial foodservice-grade brushes** | Designed for sanitation compliance; often color-coded. | Long-lasting; easy to sanitize with heat or chemicals. | (57) |
| **Ultraviolet radiation (UV)-sanitizing sponge holders** | Integrated UV-C light exposure systems. | Continuous passive disinfection; useful in the food industry. | (58) |

each use. **Table 6** shows the recommended alternatives for hygiene practices.

# Safer alternatives: challenges, cost, and performance compared to synthetics

## Market availability

Natural alternatives—such as loofah, coconut coir, cellulose, and cotton scrubbers—are increasingly available in eco-friendly stores and online marketplaces but are still less prevalent in mainstream supermarkets compared to synthetic sponges and scrubbers. Some "natural" products may contain synthetic fibers or adhesives, so consumers must check labels for truly plastic-free options.

## Cost considerations

Natural scrubbers often have a higher upfront cost than the cheapest synthetic sponges. However, well-made natural cleaning tools (such as wooden or fiber brushes and loofah sponges) can be more durable and long-lasting than low-quality plastic ones, potentially offsetting the initial investment over time. For example, single-layer loofah sponges and high-quality brushes are reported to last several months of daily use.

## Durability and real-world performance

**Natural Loofah and Fiber Scrubbers:** Natural loofah and fiber scrubbers are great cleaning tools since they gently and effectively cleanse surfaces without damaging them. They may be used for a wide range of cleaning jobs. Their fiber, porous texture helps them dry quickly, which prevents moisture from building up and makes them smell better than synthetic sponges (59). This property of drying quickly also reduces the growth of germs, which makes them cleaner when used appropriately. Loofahs are healthy for the environment since they are made from the mature fruit of the luffa plant and break down naturally. This makes them a longer-lasting alternative to plastic scrubbers (60). You may use them for a lot of tasks, including cleaning your house and

scrubbing your skin. They remain robust and work well with cleaning agents that are safe for the environment.

**Cotton Scrubbers:** Cotton scrubbers are ideal for cleaning since they are gentle yet work well. They work well on delicate surfaces and around the house every day. They can soak up liquids and manage moisture, which makes cleaning easier (61). Families with sensitive skin or those who wish to minimize their exposure to toxins in their homes can use cotton scrubbers instead of other types of scrubbers since they don't have any chemicals or synthetic colors (62). It's also a natural fiber that can be cultivated again and again and breaks down on its own. This is better for the environment since it generates less plastic waste and trash in landfills than synthetic scrubbers. Cotton scrubbers last a long time and may be used several times. You can wash them and use them again. This lowers the amount of trash and consumption (63, 64). Cotton scrubbers are an excellent option for cleaning since they are beneficial for the environment and for your skin.

**Cellulose Sponges:** Cellulose sponges are a natural and sustainable product derived from wood fibers. They originate from the cellulose polymer constituting plant cell walls, particularly prevalent in wood pulp. These sponges are produced by extracting cellulose from wood pulp, purifying it by removing lignin and other contaminants, and then molding it into a porous, highly absorbent configuration (65). Cellulose sponges decompose naturally and do not contribute to microplastic pollution, making them far more environmentally friendly than plastic-based sponges. Numerous commercial cellulose sponges are labeled as "cellulose sponges," although they often include synthetic components that diminish their biodegradability and alter their functionality. Cellulose sponges often clean as well as synthetic sponges due to their softness, absorbency, flexibility, and durability (66). This makes them an excellent option for regular use that is also environmentally friendly. The arrangement of cellulose fibers imparts strength and creates an interconnected network of pores. This facilitates rapid liquid absorption and gentle cleaning.

**Synthetic Sponges:** Easy to find and inexpensive, synthetic sponges, especially ones with rough sides, are often used to remove tough spots and dirt. Plastic polymers like polyurethane foam make up most of these sponges. They also usually have glues and manufactured fillers that don't break down in nature (67) in them. In time, friction breaks them down, releasing microplastics, which are tiny pieces of plastic less than five millimeters long. These bits get into sewers and finally hurt rivers, seas, and marine environments. According to some studies, when melamine foam sponges wear out, they may release more than 6.5 million microplastic fibers per gram. Corti et al. (68) say that this could mean that billions of these fibers are dumped into the ecosystem every month. Plastic particles called microplastics can stay in the environment for hundreds of years. They may end up in food chains and hurt the health of animals. Their dangerous nature and ability to mess with hormones mean they may also be bad for people's health. Also, using a lot of fossil fuels to make synthetic sponges adds to greenhouse gas emissions and leaves a big carbon footprint (16). Although these sponges are good for cleaning, they are very bad for the earth. This emphasizes how important it is for customers to seek out more eco-friendly and plastic-free choices to lower microplastic waste and environmental damage.

## Efficacy

Research and user testing indicate that natural fiber scrubs (loofah, coconut coir, cotton) are as effective as, or sometimes superior to, synthetic options for cleaning dishes, especially for removing stuck-on food without scratching. Their absorbency and quick-drying properties also reduce bacterial growth compared to synthetics, which tend to retain moisture and develop odors more quickly.

## Adoption challenges

There are a few big challenges with encouraging more people to use natural sponges and scrubbers. These include how people use them, how eco-friendly products are branded, and how well people perceive natural alternatives to function. People find it hard to switch to natural sponges because they are accustomed to how they feel, how well they clean, and how cheap they are. Customers usually want sponges that are cheap, last a long time, and are easy to use. Synthetic sponges usually suit these demands. This makes it impossible for eco-friendly alternatives to take over the market, even when people think they are more expensive or not as good. Another huge concern is that some things that are labeled as "natural" or "eco-friendly" yet include synthetic fibers or adhesives in them. People who wish to acquire items that are really biodegradable and chemical-free have a hard time finding them because of this. This lack of clear labeling or certification makes it difficult to get consumers to choose things that are good for the environment, and it also makes them less likely to trust the products.

Lastly, how well people believe natural scrubbers clean and how long they last are really crucial for encouraging people to purchase them. Researchers and market surveys have shown that natural sponges and fiber scrubbers absorb up water, clean softly, and last just as long as synthetic ones. Some individuals, on the other hand, are still not sure whether they can handle a lot of dirt or last a long time, which makes them less inclined to acquire them. More and more people are learning about personal care products that are excellent for the skin, hypoallergenic, and good for the environment. As a result, the demand for these products is growing. The natural sponge market is predicted to grow at a compound

annual growth rate (CAGR) of around 5% through 2030 since these anxieties are going away.

## Environmental and health benefits

Natural alternatives are biodegradable and compostable, breaking down in months rather than centuries and leaving no harmful residues. They are free from synthetic chemicals, making them safer for sensitive users and the environment.

## Commentary: natural vs synthetic scrubbers

**Market Availability:** More and more retailers and online marketplaces are selling natural scrubbers made of loofah, coconut fibers, wood, or cotton. But they are still behind synthetic sponges in terms of how many stores carry them, particularly in big-box stores and regular supermarkets. This lack of exposure might make it tougher for regular people to find or get to them. Right now, specialty and eco-friendly shops are the best places to get these items. As more people become aware of and want the product, it will likely be available in more places.

**Durability:** Natural scrubbers made from strong plant fibers like loofah or coconut coir are frequently better than cheap synthetic sponges, which tend to break down, rip, or smell bad after a short time of usage. Synthetic choices may look strong at first, but inexpensive sponges often break down rapidly, so you have to replace them often. Natural scrubbers, on the other hand, may keep their shape for months of frequent usage as long as they are cleaned and dried correctly. Their strength may help cut down on home trash and long-term expenditures of buying things.

**Efficacy:** Natural sponges, such as loofah, coconut, and cellulose sponges, work just as well as synthetic ones for cleaning dishes, surfaces, and cookware in most home situations. Some natural scrubbers are softer on nonstick cookware, according to studies and user experiences. This helps keep pans from being scratched and makes them last longer. Also, since they may be composted and dry out faster, they are less likely to hold germs and mold, which makes the kitchen cleaner over time.

**Cost:** Natural scrubbers may cost more up front than regular synthetic sponges, but their longer life may make up for the extra expense over time. The fact that they can break down in the environment or be composted adds even more value since it cuts down on trash disposal costs and damage to the ecosystem. Using natural scrubbers may be good for the environment and save money in the long run for customers who are ready to spend a little extra up front.

**Adoption:** More people will use natural scrubbers if a few things happen: more people learn about their advantages, product labels are made clearer and more consistent, and they become more widely available in regular stores. Many people who would want to purchase these items still don't know how they stack up against regular synthetics in terms of performance and long-term use. As manufacturers and activists keep spreading the word and stores provide more choices, adoption rates are likely to go up a lot.

In summary, natural scrubbers offer a sustainable, effective, and increasingly practical alternative to synthetic products, with challenges remaining primarily in consumer perception, labeling, and widespread accessibility.

## Public awareness and recommendations

Educating the public about the health hazards associated with cleaning products and promoting safe usage is crucial. Møretrø et al. (5) found that individual cleaning practices significantly impact bacterial growth on cleaning implements, indicating a need for increased public knowledge. Alwan et al. (69) observed that, although individuals were proficient in using household disinfectants, awareness remained low. Targeted public campaigns and clear product labeling, along with regulatory guidelines and training programs, can help improve hygiene and reduce health risks.

## Future research directions

**Long-Term Efficacy Studies**: To find out how well natural fiber scrubbers, microfiber cloths, and other potential eco-friendly options kill germs and clean, we need to do long-term, in-depth comparisons. Most of the evidence we have so far is based on short-term lab circumstances that may not be the same as how we use our kitchens every day, such as going through wet and dry cycles and being among different food residues. To provide useful suggestions on safety and performance, we need to do field research in the real world with a wide range of user behaviors and settings. These studies might help customers and authorities find the solutions that are the most sanitary, long-lasting, and environmentally friendly. Filling up these gaps would also make it possible to find the best ways to disinfect diverse materials.

**Innovative Disinfection Methods:** To improve hygiene and lower the danger of pathogenic contamination, it is important to look into novel, easy-to-use ways to disinfect cleaning instruments for homes and businesses. Technologies like UV-C irradiation, ozone-based cleaning, and antimicrobial coatings show promise, but more research is needed to find out how safe, affordable, and easy they are to use (70). To really know how well these technologies work and how well they work with different materials, we

need to test them in household and food service settings where they are used a lot. These kinds of changes might make it harder for microbes to survive and make people more confident in using natural and reusable items. Working with engineers and health experts will be very important for turning prototypes into solutions that can be used by many people (71, 72).

**Environmental Impact Assessments:** Strong life-cycle assessment (LCA) studies are needed to correctly measure how environmentally friendly kitchen cleaning products are. These should look at how the raw materials are sourced, how much pollution is caused by production, how the product is transported, how consumers use it, how much microplastic it sheds, how quickly it breaks down, and how it is disposed of at the end of its life. Comparative LCAs of synthetic options (like polyurethane sponges) and natural options (like loofah, cellulose, and coconut fibers) may show how they differ in terms of water, carbon, and toxin footprints. This big-picture view is important for making sure that product design and policy do as little damage to the environment as possible, particularly because microplastic pollution is becoming a bigger problem.

**Consumer Behavior and Education:** To make successful instructional programs, we need to do empirical study on how people feel, think, and behave when it comes to choosing cleaning products. Knowing what stops people from using safer and more environmentally friendly methods, such as how much they think they would cost, how acquainted they are with the products, or false information, may help you plan focused ads and nudges. Longitudinal and behavioral studies may also look at which methods work best to get people to make long-lasting changes in their kitchen hygiene and eco-friendly behaviors. To get people to change their behavior on a big scale, it's important to raise public awareness and back it up with clear, evidence-based messages.

**Policy and Industry Standards:** It is very important to have clear industry standards, clear labeling, and rules that deal with the safety, health, and environmental claims made by cleaning product makers. Clear and enforced rules would help stop greenwashing, keep customers safe from false advertising, and encourage the use of really safe and eco-friendly products. To set certification standards and make testing procedures the same all over the world, policymakers, scientists, and people in the business need to work together. Standardizing things like this helps the market expand for better options and makes sure that people trust eco-friendly and health-promoting items.

In summary, moving forward requires a collaborative effort among researchers, industry, and consumers to prioritize healthy, effective, and environmentally responsible cleaning solutions for kitchens. Regular replacement of sponges, adoption of advanced sanitization technologies, and ongoing research into safer alternatives will be key to reducing risks and promoting sustainable hygiene practices.

## Conclusion

Kitchen scrubs and sponges, while essential for maintaining cleanliness, can pose substantial health and environmental risks if misused or neglected. The combination of physical wear, chemical leaching, microbiological colonization, and non-biodegradable waste underscores the need for more responsible usage and safer alternatives. Evidence supports the use of natural fiber scrubbers, microfiber cloths, and biodegradable detergents, as well as enhanced hygiene measures such as frequent disinfection and replacement. To minimize health risks, it is advisable to replace kitchen sponges every 5–7 days in domestic settings. In commercial kitchens, the adoption of UV-sanitizing holders or similar advanced disinfection technologies can further reduce microbial contamination and cross-infection risks.

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