The correlation between sustainable development and home hygiene

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Hygiene refers to the science of the establishment and maintenance of (human) health. In everyday life, hygiene is closely associated with good housekeeping. This article will focus on home hygiene in relation to cleaning, on microorganisms, and on sustainable development of domestic technology. In domestic cleaning there are two beneficial effects: the aesthetic aspects of cleanliness and the removal of microorganisms. In cleaning science substantial attention is paid to the interrelation between cleaning and removal of microorganisms. It appears that the parameters of the cleaning process and the detergent properties play a significant role in this interrelation. Changing technology to reduce the environmental impact of household cleaning not only influences the household activities and the functional performance of the cleaning processes but also has an impact on the level of hygiene. Results are presented of research in which the hygiene has been evaluated in relation to such changes. One option recently studied to reduce the environmental impact of households is the reduction of water consumption by water reuse. In such concepts water is used in successive steps for various processes before it is drained. The potential impact of such systems and of the use of rain water on the level of home hygiene is discussed. (Am J Infect Control 2001;29:211-7)

In the past decades many processes and activities in the home have been modified to reduce their environmental impact. No substantial attention has been paid to the possible influence of these changes on the level of hygiene in the home. In the first part of this article, a review of the impact of household cleaning on hygiene in private households will be outlined. In the second part the interaction between sustainable development and sustainability measures and the quality of hygiene in the home will be analyzed.

Hygiene and cleaning in the home

Household cleaning is primarily meant to remove visible soil and stains from the home environment. The cleaning processes applied are especially designed to achieve this aesthetic effect, and the members of the household will assess the level of cleanliness by visual judgement. The occurrence of malodors and “sticky layers” on contact surfaces is often regarded as an indicator for improper cleaning. Their removal is therefore an important objective of household cleaning too.

Other perceivable benefits of cleaning are the restoration of the original appearance of the material, such as removal of creases by textile laundering.

It should be realized, however, that the achievement of adequate hygiene is a very important aspect of household cleaning. During many cleaning activities a substantial reduction of the amounts of microorganisms takes place. In cleaning research substantial attention is paid to the interrelation between cleaning and disinfection. There are, however, no direct indicators for the quality of the hygiene in the home.

An infectious disease can result from direct contact between a sick person and a potential victim. But it can also result from contact with an environment when there
is no obvious direct contact between source and victim of an infection. For example, a towel is an inanimate object, but if it is sucked by a child with scarlet fever and then by a second child, the organism causing the disease can be transmitted to the second child. Many such objects, a handkerchief, a toy, or a towel, for example, may transmit infection under appropriate conditions.

There are other ways in which microorganisms can be transmitted from source to victim and are therefore likely to cause risks of infection for human beings. In the home, food preparation is one of the most important sources of infection. In general, soil adhering to surfaces does not necessarily cause hygienic effects. But in moist conditions the soil may function as a medium for microorganisms, enabling them to grow and to cause malodors. In certain environments the microorganisms in the adhering soil are likely to cause significant risks of infection to human beings. In kitchens, microorganisms grown on adhering soil can spread easily. Research by Borneff et al.\(^1\) showed that during the preparation of a dinner, microorganisms in contaminated chopped meat were spread over all the utensils and working surfaces used, thus infecting all the food prepared. The same may occur when microorganisms are present on the utensils and working surfaces. Other examples in which microorganisms on surfaces may cause risks are environments where intensive contact with bare skin occurs, such as in bathrooms, swimming pools, and sports facilities.

In the previous examples the microorganisms adhering to the surface of an object are transmitted to the victim through contact with the object. But there are more ways in which microorganisms can be transmitted from a source to a victim. In this context it is worth mentioning the infectious potential of dust. Dust is perhaps one of the most common inanimate elements capable of transmitting disease. Dust itself cannot cause infectious diseases, but organisms present in dust may get on food and be eaten, settle on the skin, or be inhaled into the respiratory passages.\(^2\) However, in situations with an extremely high dust concentration, dust can trigger an infection with microorganisms already present.

Apart from infectious diseases, dust, when inhaled into the respiratory passages, can cause a number of other diseases. Examples are allergies, asthma, hay fever, and chronic bronchitis.\(^3\) In the following paragraphs it will be shown how different cleaning processes may affect the level of hygiene.

**Textile cleaning**

In theory infectious diseases can result from contact with contaminated textile articles and garments. Many such objects (such as a handkerchief, a toy, or a sock, for example) may transmit infection under appropriate conditions. The impact of inadequate laundry hygiene on human health is difficult to assess. However, under certain conditions cross-contamination with pathogenic organisms may represent a health risk. Examples are yeasts and fungal dermatophytes causing diseases, such as athlete’s foot and jock itch.\(^4\) For that reason textile cleaning in private and institutional environments is a determining factor for appropriate hygiene.\(^5\) The primary object of the laundering process is the restoration of the fitness for use and the aesthetic properties of the textiles; that is, removal of soil, stains, and creases. During the usage period textile articles are contaminated with visible soil and invisible microorganisms. The latter may become evident to consumers if present in too high amounts and under certain conditions in the form of biofilms on the inner surfaces of washing machines, unpleasant odors, or visible mold growth on the textiles. The additional benefit of the laundering process is the maintenance of appropriate hygiene. In this context the latter is considered as the control of microorganisms so that they do not pose a threat to human health.

**Physical removal of microorganisms.** In a household washing process the main hygienic effect is probably due to the removal of the dirt itself; when dirt is removed well, the microorganisms are removed with it. During the main wash of a washing process, the soil and the microorganisms will be suspended, and after that most of the microorganisms will be drained off in one of the rinses. This is referred to as the physical removal. Microorganisms packed in soil aggregates on the laundry surface can survive severe washing conditions, meaning that a cleaning process with inadequate soil removal inevitably leads to insufficient hygienic qualities. Furthermore, dirt that remains after the washing process can serve as a medium for microorganisms; clean laundry is an inhospitable host.

The degree of soiling of the laundry before washing influences the hygienic quality of the washed laundry. The higher the initial degree of soiling, the lower the hygienic quality of the washed textiles. A higher rinsing efficiency improves the removal of soil and microorganisms in a washing process.

In washing processes with very mild conditions microorganisms may even be able to grow. In such cases a longer washing time will have a negative effect on the laundry hygiene.

**Thermal disinfection.** In addition to physical removal, microorganisms can be killed by heat. When suspended in the suds, the microorganisms are sensitive to temperature and chemical disinfectants and are killed easily.\(^6\) In general a higher temperature speeds up thermal disinfection. In a study on hygiene conducted in 1989 with wash tests with heavy-duty detergent and in a household washing machine, Ainsworth and Fletcher\(^7\) showed that *Enterococcus faecalis* applied on textile fabric was
removed much better at 50°C than at 30°C; the difference is about 3 log units. Cross-contamination was found at both temperatures but substantially more at the lower temperature. In another research carried out in 1989 as well, Ainsworth and Davis showed that both for a heavy-duty powder with activated bleach and for a liquid detergent the disinfection was substantially better at 50°C than at 30°C.

It should be noted that the results of Ainsworth's investigations might give too-optimistic values, because the tests were carried out with artificially applied test organisms. In normal laundry the organisms occur in soil aggregates that make them more persistent. This has been shown by Raschle and Terpstra et al for the household situation. Both found substantially lower disinfection values in tests in which normally soiled laundry was used. In his research Raschle even found an increased number of bacteria after a washing process at 30°C with dirty laundry. The results of this research are shown in Table 1.

**Chemical disinfection.** In household laundering, chemical disinfection can be achieved by various detergent components. Examples of the ones most used are tetraacetylethylenediamine/persalt combinations, percarbonate, perborate, and sometimes dichloroisocyanurate. Hypochlorite bleach in the last rinse of the washing process or separately after the washing process also achieves a perfect disinfection.

High pH values have a conserving effect; this means that generally microorganisms will not be killed, but their growth will be impeded. High-alkaline detergents are therefore assumed to have a positive effect on laundry hygiene.

**Cleaning of hard and soft surfaces and of the inner environment**

With regard to textile cleaning, the primary object of the cleaning of the inner environment is the restoration of its fitness for use and its aesthetic properties. In this case the main effects of cleaning are the removal of adhering soil and invisible dust from the surfaces of the objects. In environments where risks of infection occur; cleaning the surfaces may be combined with disinfection.

In private and institutional households, particularly in kitchens and sanitary environments, hard surfaces may be cleaned with cleaning agents containing hypochlorite. Borneff et al found that careful disinfection with a 0.5% hypochlorite solution after cleaning is a proper way to eliminate the contamination in kitchens. It has been shown by Scott et al that the use of hypochlorite and phenolic disinfectants results in a substantially better hygiene quality in kitchens, bathrooms, and toilets than the use of hot detergent solutions. Other chemicals used for disinfection of hard surfaces are quaternary ammonium compounds, persalts, dichloroisocyanurate, and peracetic acid.

Dust particles are transported through the inner environment with air used as a transport medium. The concentration in the ambient air is interrelated to the amount of dust on the inner surfaces and the degree of air movement. The type of surface plays a dominant role in this interrelation. Low dust levels in the ambient air can be achieved by regular removal of dust from the various hard and soft inner surfaces. This can be done with proper cleaning techniques in combination with appropriate maintenance programs. Techniques generally used for dust removal are vacuum cleaning, sweeping, brushing, and removal with a dry, impregnated, or damp textile cloth.

But even with proper cleaning methods and an intensive maintenance schedule, household environments cannot be maintained dust free. Dust will inevitably be deposited on places that cannot be accessed by the cleaning personnel. Older buildings are notorious for this. Dust will also accumulate in soft floor coverings. Research on the efficacy of vacuum cleaning showed that, even with a very intensive cleaning schedule, dust accumulates rapidly in soft floor coverings. In a study in which the accumulation of dust in carpets in simulated real-life condition was
assessed, the dust build-up for a situation in which during 5 weeks a carpet was soiled with dust daily (5 days a week) and cleaned with a vacuum cleaner once a week reached 250 g/m². The experiments were run with various types of vacuum cleaners and different floor coverings; all resulted in a dust accumulation of a similar magnitude. The dust accumulated in this way could not be removed substantially with any of the common cleaning methods. During the daily activities in the home a part of the accumulated dust will be recirculated in the ambient air.

**Sustainability and sustainability measures**

Since the report of the Club of Rome in 1967 and the energy crisis in the 1970s, our society has gradually become aware that human beings use and pollute more than the ecosystem can supply and bear. In a situation of a durable equilibrium, no more raw materials are used than the ecosystem can supply, and no more waste is drained off than the system can clear. Brundtland\(^6\) called this durably balanced situation *sustainability*—living in harmony with the environment so that there will be a liveable world for present and future generations.

Environmental impact effects are often subdivided into 3 classes: depletion of natural resources, pollution of the ecosystem, and degradation of the biodiversity. Household cleaning significantly contributes to the first two classes. The impact on the third class, the degradation of the biodiversity, is difficult to assess.

Although good drinking water is becoming scarce in many countries, the household water consumption has increased in the past decades. In The Netherlands about 25% of the household water consumption is due to textile cleaning and dishwashing.\(^1\) Textile washing and dishwashing are also responsible for a significant part (about 20%) of the domestic energy consumption. And nonrecoverable raw materials are used for the production of detergents. At the output side of the household system, the drained wastewater burdens water clearing plants and the surface waters. The other cleaning activities tax the environment through water and energy consumption and waste production as well, although to a lesser extent.

Because of these environmental effects, the goal of a sustainable society has influenced household and institutional cleaning processes significantly over the past few years. Hereafter it will be shown that the measures that have been taken to protect the environment not only affect the environmental impact of cleaning processes but also influence the product performance and level of hygiene in the households.

**Reduced energy consumption.** In an attempt to reduce the energy consumption of household cleaning, the process temperatures for washing and dishwashing have been lowered. Traditionally heavily soiled laundry such as kitchen towels, underwear, and bed sheets was washed with a white wash program at 95°C; the so-called boiling program. Lightly soiled garments such as blouses, dresses, shirts, and skirts, mostly colored articles, were washed in a washing program at 60°C. Because a substantial part of the energy consumption is due to heating water, the wash temperatures of the above-mentioned programs have been reduced to 60°C and 40°C, respectively.\(^1\) To maintain an acceptable cleaning performance, the duration of the main wash and the mechanical action have both been increased. But even then the soil removal is lower in comparison with the programs with higher wash temperatures. Several consumer bodies and researchers reported a lower cleaning performance for these low-temperature programs.\(^1\)\(^,\)\(^2\)\(^0\)

The lower cleaning performance is also reflected in the hygienic performance. As shown in the previous paragraphs, a lower wash temperature leads to a lower hygienic quality of the washing process. In his research Raschle\(^6\) even found an increased number of bacteria after a washing process at 30°C with a load of dirty laundry. To summarize, it may be stated that for domestic textile laundering the measures to reduce the energy consumption have a negative effect on the conditions for appropriate hygiene.

For dishwashing the picture is comparable. Here also a large part of the energy needed for a cleaning process is used to heat the process water. This implies that energy is saved when the washing temperature is lowered. The traditional dishwashing temperature is 65°C. For energy-saving reasons the 55°C program has been introduced. As with laundering, this lower temperature will have a negative effect on the cleaning performance. And this in turn is likely to have a negative effect on the hygienic conditions. Contrary to the situation concerning laundering, no empirical research data are available to support this statement.

The impact of energy saving on the hygienic properties of hard-surface cleaning and carpet cleaning is more difficult to assess. It may be that the dust removal potential of low-energy vacuum cleaners is lower than that of conventional ones. And it might also be that for energy-saving reasons, less hot water is used for hard-surface cleaning. But these are just hypotheses for which there is no substantial evidence. It is uncertain whether energy saving has an impact on the hygienic properties of domestic hard-surface cleaning and vacuum cleaning.

**Reduced water consumption.** To reduce household water consumption, various cleaning processes have been adapted. In washing and dishwashing machines,
the water levels in the wash and rinse phases have been lowered and, where applicable, one or two rinse cycles have been eliminated. These changes, however, are likely to have an influence on the performance as well. Both measures will lower the rinsing efficiency and therefore leave more soil, including microorganisms, in the washed laundry or on the dishes. To compensate for this reduction in water level, the rinsing programs have been modified. It is questionable whether this can provide enough compensation. There is no evidence that water-saving measures have affected other cleaning processes.

**Reduced use of chemicals with a view to pollution.**

The use of cleaning agents is linked with the depletion of natural resources used for the production of these chemicals. But it is also linked with pollution of the aquatic system, because the used detergents are drained with the wastewater. In an attempt to reduce these impacts, detergents have been made more effective and have been concentrated, with both measures leading to lower detergent consumption. In The Netherlands, for example, the dosage for a normal washing program for white clothes has gone down from 170 g/cycle in 1980 to 65 g/cycle in 2000. For dishwashing these figures are 30 and 20 g/cycle wash cycle, respectively. This reduction leads to lower detergent concentrations in the suds, which is likely to reduce their contribution to the chemical disinfection in the washing process. Therefore it is doubtful whether the performance and hygienic properties of a process with this reduced detergent dosage are still at the original level.

A number of chemicals in cleaning agents have been substituted by others or deleted to reduce their contribution to pollution. An example of this is tripolyphosphate. The builder tripolyphosphate shows undeniable washing qualities. In a number of countries, however, this builder has been replaced by less effective builders because of its eutrophic properties.

At lower washing temperatures bleach systems that are based on persalts are much less effective for soil removal and as a disinfectant. This adverse effect can be compensated for substantially by the addition of bleach activators, such as tetraacetylene diamine. At low washing temperatures the effectiveness of activated bleach systems decreases as well. Detergents for colored articles meant for washing temperatures of 60°C and lower do not contain bleach and will therefore show poor qualities of disinfection.

Hypochlorite, used in the last rinse of a washing process or as an ingredient of hard surface cleaners, shows perfect qualities as a disinfectant. As a result of its capacity to form halogenated organic compounds, some of which are suspected of being carcinogenic in the presence of organic chemicals, it is in the public interest to ban or discourage the use of hypochlorite. Because hypochlorite is a superb disinfectant, this will affect the level of household hygiene.

The effects of the various environmental measures on domestic hygiene are compiled in Table 2. To summarize, it may be stated that the measures taken to reduce the environmental impact of household cleaning processes have had a negative effect on the conditions for appropriate hygiene.

**Future prospects**

In the previous paragraphs the impact of measures taken in the past on the level of hygiene in the home has been outlined. But what developments are to be expected for the future and what will be their effect on hygiene?

First of all it may be noted that the efforts to reduce domestic energy and water consumption will continue. The European community, for example, discusses the possibility of focusing the energy labeling for domestic appliances on 40°C instead of the present 60°C, with the aim of lowering wash temperatures further. And the European Union has initiated a research program that is focused on the development and evaluation of options to reduce the water and energy consumption of households further. In the scope of water saving, research to study the feasibility of reuse of water in the homes has been initiated. The idea behind this approach is that water that has been used but is still relatively unpolluted can be applied for functions for which clean water is not required. Examples are the use of bath and shower water,
for textile washing, or toilet flushing. In this connection the use of rainwater and river and lake water for these functions is studied as well. This implies that the influence of water and energy reduction measures on home hygiene is likely to continue.

A similar picture appears for the use of household chemicals. The elimination of harmful chemicals in cleaning products and the reduction in quantities used are both likely to continue, as will their influence on home hygiene.

Consumer associations and governments inform consumers about the ways to lower water and energy consumption without affecting the functional quality. For this purpose, for example, the European Energy- and ECO-labeling system has been introduced. Through these information systems consumers are informed about the environmental impact and the functional quality of consumer products. The hygienic quality of the products is not considered in any of these information sources.

The International Electrotechnical Commission, the International Standardisation Organisation, and their European counterparts CEN and CENELEC publish and develop testing methods to assess the quality of consumer products for household cleaning. This means that product developers and manufacturers are neither alerted to the relevance of hygiene nor do they get the tools to assess this issue.

**Conclusions and discussion**

A number of household cleaning processes are determined for the level of hygiene in the home. It may be concluded that a number of measures that have been taken in the past to reduce the environmental impact of household cleaning have had a negative effect on the conditions for appropriate hygiene.

There is strong evidence that further measures to reduce the environmental impact of household activities will be introduced. This in turn will put more stress on hygienic conditions.

On the other hand product developers, manufacturers, consumer organizations, and governmental bodies do not seem to realize the role of household cleaning products in maintaining hygiene and the implications of environmental measures in the home.

Because it is clear that the above-mentioned developments endanger the level of home hygiene, solutions must be creative. It makes no sense to try to stop sustainable development. One should realize, however, that high levels of hygiene are not required in all situations. Targeted hygiene might therefore be an approach that is compatible with sustainable development. This means that practices with high hygienic quality are used only in those situations where high hygienic levels are necessary. In addition all those who operate in this field should be better informed about the conditions for appropriate home hygiene. To enable households to make the right choices for their practices, it is desirable to inform them about the hygienic properties of consumer goods and processes. Product hygienists should be aware of this and should look for ways to solve these problems before they affect the quality of public health.

**References**


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