- The major recommendations from several expert panels held since 1990 are still appropriate. These recommendations, if addressed, should advance the public health response to the public's concerns about MCS.
- Information on the fiscal cost of MCS to society is scarce. The fiscal outlay required for or involved in medical diagnosis and treatment of MCS needs additional study.
- Only limited efforts are being made by US federal health and environmental agencies to communicate to healthcare providers what is known and not known about MCS.
- Numerous therapies aimed at treating MCS have been identified in the literature; however, no widely accepted protocols are proven to be effective in addressing MCS symptomatology. Therapeutic interventions that claim to effectively address or minimize these impacts need objective study and validation.
- While study and validation of therapeutic interventions continue, the goal of patient care should be to promote health without causing harm.

Research Priorities

The workgroup concludes that current budget constraints make it unlikely that MCS will obtain extensive research support, especially in light of similar and somewhat related conditions that also are reported to have disabling effects but have insufficient clinical evidence of disease. These include chronic fatigue syndrome, fibromyalgia, and Gulf War-related illnesses. However, the group identifies research needs in the case of MCS. Among the recommendations:

- Researchers need comprehensive biomedical and clinical data for a consensus case definition to use in epidemiological studies and clinical evaluations. This would require studying MCS patients under controlled conditions.
- Another key requisite is data on the prevalence of MCS and related disabilities.
- Researchers should use standardized and validated tools to collect data on the psychosocial factors in MCS.
- Scientists need to develop models of the pathophysiological mechanisms that might be associated with MCS. Animal models that could help identify biomarkers in humans are important in this effort.
- The research effort needs well-coordinated, multicenter studies to detect or exclude the subtle effects that may be associated with low exposures and idiosyncratic reactions. This would require blinded assessments, testable hypotheses, and objective outcome measures.
- Until a consensus case definition is available, individual researchers should describe their operational definition in sufficient detail so that others can attempt to reproduce the findings.
- Because no widely accepted protocols have proven to be effective in treating MCS, the therapeutic interventions claimed to be effective need objective study and validation.

The workgroup is seeking comments on the draft report and will accept them until October 30. To obtain a copy or submit comments, contact ATSDR Information Center, 1600 Clifton Road, Mail Stop E57, Atlanta, GA 30333. Tel: (800) 447-1544. The workgroup has reminded potential respondents that all information submitted will become public and advises people not to send personal medical information they wish to keep confidential.

Practical Research Briefs

Washing Machines, Dishwashers Potential Sources of Indoor Air Pollution

Few people think of their washing machine or dishwasher as a source of indoor air contaminants, but recent research from the University of Texas (Austin, Texas) indicates that these devices are extremely effective at removing chemical contaminants from water and emitting them into the indoor environment.

Richard Corsi from the university's Center for Energy and Environmental Resources program conducted the research under a grant from the

US Environmental Protection Agency (EPA). He tells ***IEQS*** that washing machines and automatic dishwashers are more efficient than showers at stripping and volatilizing such chemicals as those used in water disinfection or that come from groundwater contamination. Previous research on the subject focused almost entirely on showers. Corsi says bathtubs may prove to be an overlooked source, as tubs are almost as efficient as showers at stripping chemicals, but pose a greater risk because people tend to spend much more time in a bathtub than they do in a shower.

While many people are concerned about contaminant exposure from ingesting chemicals in drinking water, inhalation may prove to be a more significant exposure route for several reasons. Other research indicates that inhalation is a more efficient way of getting chemicals into the bloodstream than ingestion; also, in an environment such as a shower or bathtub, occupants can actually accumulate high levels of chemicals in the gas phase. Corsi tells ***IEQS***, "It's possible to inhale a greater quantity in terms of total mass than someone would drink in a liter or two of water per day. Basically, it's just a mass uptake problem."

While it may seem that a washing machine, especially with the lid closed, would pose little problem, Corsi says that the machines are actually well-ventilated, both through the lid and the casing. When you use hot water in a washing machine, he explains, you create a kind of "chimney effect" and can get ventilation rates in excess of 100 liters per minute. Dishwashers, on the other hand, are less well-ventilated, but are more efficient at stripping chemicals from water. This comes from their mechanical action, which consists of rotating arms that emit water droplets and smash them against the walls of the machine. Also, the higher heat in a dishwasher tends to drive chemicals out of the water and into the headspace, which is greater in a dishwasher than in a washing machine.

According to Corsi, dishwashers tend to have a ventilation rate between 5 liters and 7 liters per minute. However, when someone opens the door, the chemicals that are in the headspace come out in a "puff," releasing them into the room air.

Corsi didn't develop any risk models for commonly found water contaminants. The purpose of the research was to develop a database that could be used to determine fundamental mass transfer coefficients from water use under various conditions. EPA is currently looking at drinking water standards with an eye toward determining whether pollutant pathways other than ingestion pose significant risk to the public. Corsi says the agency plans to use his work to look at inhalation exposure.

The Research

The Texas study involved nearly 120 experiments using five tracer chemicals: acetone, ethyl acetate, toluene, ethylbenzene, and cyclohexane. Rather than testing local water, the researchers added the chemicals to the water for the experiment, with the choices of chemicals representing a wide spectrum of volatility. Each set of experiments set out to determine:

- Chemical stripping efficiency
- Mass transfer coefficients: overall, liquid, and gas-phase
- The importance of gas-phase resistance to mass transfer

Showers

For the shower emission portion of the testing, the researchers bought and installed a commercially available tub-shower unit and adapted it to their purposes. They installed water sampling and gas sampling ports, allowing them to monitor contaminant emissions during simulated shower events. For a water supply, they used a washing machine, later used in the washing machine experiment. They filled the machine's tub with water, added the chemicals under study, and then pumped the water from the machine to the shower. The washing machine's agitating action allowed them to mix the chemicals thoroughly.

An adjustable shower head allowed the researchers to switch between high and low flow rates with coarse spray and fine spray, and they used water temperatures of 22°C and 35°C (72°F and 95°F). This resulted in a 2x2x2 factorial array for the experiments. Each shower experiment lasted eight minutes, during which the researchers collected water samples at four intervals.

Gas sampling ports were located near the tub's faucet under the shower head, at the top of the shower enclosure, and toward the back wall of the enclosure. The researchers took a total of 12 gas samples during each experiment: 6 from the port in the top of the enclosure and 3 from each of the other two ports.

Dishwashers

For the dishwasher experiments, the researchers used a commercially available machine with an interior volume of 188 liters. The researchers added a gas sampling port at the top rear of the machine and a liquid sampling port at the bottom. For this experiment, they also used a 2x2x2 factorial array, testing under various conditions: rinse cycle or wash cycle, empty or full, and water temperatures of 41°C or 54°C (106°F or 129°F). The researchers allowed the dishwasher to fill and then added the tracer chemicals. The experiments lasted 10 minutes, and liquid samples were taken at five different intervals during the cycle. Researchers took a total of four gas samples during the testing.

Washing Machines

Washing machine experiments differed because of the operating cycles of a typical machine, which include a fill cycle and a wash/rinse cycle. The researchers reported that the fill cycle has different mass transfer mechanisms than either the wash or rinse cycles, which are similar to each other. So, they divided the experiments into two groups.

For both sets of experiments, the researchers used a commercially available machine with a total interior volume of 150 liters. They adapted the machine by adding sampling ports in the lid. For each experiment, the researchers manipulated several operating conditions, including the flow rate, water temperature, presence or absence of detergent, water volume, and the presence or absence of clothes.

For the wash/rinse experiments, the researchers used the same machine and this time used two 2x2x2 factorial designs. In the first set of experiments performed with detergent, the combination of variables included rinse or wash, cold or hot water, and clothes or no clothes. In the second set, the variables included slow or fast agitation, cold or hot water, and high or low volume. The researchers took 12 liquid samples and 6 gas samples during the experiments.

Bathtubs

For the bathtub experiments, the researchers used three scenarios: a flow-through experiment, tub fill testing, and surface volatilization experiments in which a simulated person was placed in the tub and manipulated by ropes. For these experiments, the researchers used the same tub/shower assembly that was used in the shower experiments.

Results

The researchers found that the machines sometimes had very high stripping efficiencies — the ability of the machines to remove contaminants from the water and transfer them to the air (see results in Table 1). For showers, the efficiency ranged from 6.3% to 80%; bathtubs, 2.6% to 69%; dishwashers, 18% to 100%; and

Table 1 — Results from Water Contaminants Tests

Chemical	Showers	Bathtubs[a]	Dishwashers	Washing Machines[b]
Acetone	6.3-16	2.6-14	18-55	3.8-38
Ethyl acetate	15-36	4.6-16	*	*
Toluene	61-77	35-53	96-98	30-99
Ehtylbenzene	62-75	33-54	97-98	31-99
Cyclohexane	65-80	64-69	100	40-100
k_g/k_l	110-223	Flow through: 37-96	*	Fill: 4.5-20
		Fill: 27-77		Wash/rinse: 0.13 - 8.6
		Bathing: 54-78		

Source: Corsi et al.

* Unable to determine.

[a] Stripping efficiency based on combined effects of filling and bathing (20 minutes) in series.

[b] Stripping efficiency based on combined effects of fill and wash (or rinse) in series.

washing machines, 3.8% to 100%. They say that acetone and cyclohexane always defined the lower and upper bounds, respectively, of these ranges. The researchers also calculated the mass transfer coefficients for the various devices. These are represented by k_g for the gas phase coefficient and k_l for the liquid phase. The researchers conclude that system operating conditions, as well as chemical volatility, can have significant effects on emissions. For chemicals with higher volatility — those with Henry's law constants greater than toluene — the variation can be as much as 30%. However, their report notes that water temperature appears to have the greatest effect over all sources and chemicals.

For more information, contact Richard Corsi, J.J. Pickle Research Campus, Center for Energy and Environmental Resources, 10100 Burnet Road, Austin, TX 78758. Tel: (512) 475-8617; Fax: (512) 471-1729; E-mail: corsi@mail.utexas.edu.

Study Shows Humidity Control, Cleaning Can Reduce Mite Infestations

Humidity control and aggressive housecleaning seem to be effective in combating dust mites and their allergens, even in homes with wall-to-wall carpeting. That's the indication from a recent study of 10 homes in the warm and humid southeastern region of the US.

Researchers from the Florida Solar Energy Center of the University of Central Florida and the University of South Florida Medical College conducted the research under a grant from the US Department of Energy. The results were presented at a workshop on mites, asthma, and domestic design in Wellington, New Zealand.

The 10 homes consist of both conventional houses and test houses that contained additional humidity control. Four of the five test houses are "Health Houses," developed by the American Lung Association (ALA) and built as a project of local ALA affiliates. All houses in the study contained instruments to measure floor-level temperature and relative humidity (RH). The researchers collected dust samples every one or two months. All except one of the houses in the study have wall-to-wall carpeting in the master bedroom and family rooms areas. Four houses are located in Orlando, Florida; two in New Orleans, Louisiana; two in Huntsville, Alabama; and two in Jacksonville, Florida.

For ventilation, the four Health Houses (HHs) use either a vapor compression dehumidifier/ventilator (DV) system or an energy recovery ventilation (ERV) system using a desiccant wheel. One of the conventional houses also has a DV system. The other five houses served as controls. Table 2 shows the characteristics of the test houses.

Results

House C1

In this house, the occupants used the vacuum regularly. It showed low levels of dust mites and mite allergen until the last month of the sampling. The house had high interior RH levels for the two months prior to the increase in mites. The researchers report that all the high dust mite levels came from the family room carpet.

House C2

According to the researchers, this house had poor cleaning practices and experienced high RH levels in the winter. The study found significant mite allergens throughout the year.

Orlando HH

For this house, the room air RH average never exceeded 50%, although there were considerable fluctuations. Also, the carpet RH averaged about 5% to 7% higher than the room air. The mite levels in this house were high. The researchers report that the furnishings in the house came from the occupants' previous home, which had been very humid. Also, the occupants used a regular vacuum cleaner with regular bags.

Orlando DV

The DV system in this house is ducted differently than that in the HH. Researchers report that the RH was controlled in all months. The occupants vacuumed frequently and used deluxe bags. The sampling indicated that the house had negligible mites and mite allergens.