CHEMICAL HAZARDS IN FLOODS & DISASTERS

- FUELS -

Link to Fact Sheet

Link to PDF version of this report

Floods and other disasters often cause hazardous chemicals such as gasoline and diesel to spill out of vehicles, industrial facilities, fuel supplies, and other sources. These can pose health hazards to the general public and cleanup workers. This website provides information on petroleum hydrocarbon fuels ("fuels" for simplicity), including gasoline, diesel, and related fuels. It supplements government agency websites that focus on bacteria, mold, asbestos, physical trauma and other hazards.

Information is provided on the following topics:

The level of hazard that exists is determined by the mixture of chemicals that are present, their concentrations in air, water, food or on land, exposures of the population, the susceptibility of people who are exposed, and other factors. Fuels are one of many types of chemical contaminants that may be present. It is important to identify the spectrum of toxic chemicals present whenever possible.

This website provides technical information based on peer-reviewed scientific information and was prepared by volunteers (see "Authors"), in the interest of public health. Quotes with attribution can be used by nonprofit organizations. Content is not approved for use by for profit entities without the authors written permission. No part of this website constitutes medical advice.

HEALTH EFFECTS OF FUELS

Many chemicals in fuels can cause health effects, depending on exposure, susceptibility and other factors. Individual responses can vary greatly, even with the same amount of exposure. Just as people respond differently to the same dose of a medication, or cigarette smoke, individual responses to chemical exposures cannot be fully predicted. A number of health effects have been well documented following exposure to fuels and their individual chemical ingredients. These are described below. Medical practice guidelines regarding the evaluation and management of health impacts have been developed by federal agencies and other medical resources listed in Additional Information.

The potential health effects of any product or chemical ingredient depends on the combination of chemicals present. The chemical composition of fuels involves a core of chemicals that are similar and fuels often contain additives . Gasoline is a mixture of over 500 hydrocarbons including straight chain, branched, and cyclic compounds with 5 to12 carbon atoms (http://www.elmhurst.edu/~chm/vchembook/514gasoline.html). Additional chemicals are present in gasoline that serve various functions in engine performance. The exact composition of fuels varies depending on the use, climate, and other factors. Consequently, the toxicity varies somewhat. However, many potential health effects are common to most fuels and the toxicity of some ingredients are well known.

This section discusses both hydrocarbon-based fuels in general and some of the well-studied chemical ingredients. Benzene, toluene, xylene, and ethylbenzene (BTEX) are the most commonly referred to ingredients when discussing gasoline and diesel toxicity and are the focus of the information below. BTEX and many other fuel ingredients can enter the bloodstream rapidly after inhalation and can be absorbed through the skin, moving into the circulation. Once in the bloodstream, they reach all of the organs in the body where they can cause toxic effects.

Common Health Effects of Hydrocarbon-based Fuels

“Occupational and Environmental Medicine” (LaDou 2007, see pages 496-501) is a standard medical textbook that provides detailed information on potential medical consequences of exposure to common fuel ingredients, including aliphatic, aromatic, alicyclic hydrocarbons and petroleum distillates. They report many health effects that are common across these groups and are relevant to fuels:

Following acute (high level short term) exposure:

- Anesthesia (central nervous system depression): dizziness, headache, nausea, vomiting, fatigue, slurred speech, disorientation, depression, disequilibrium, a loss of consciousness
- Respiratory tract irritation following inhalation: cough and sore nose and throat

Following chronic (lower level long term) exposure:

- Dermatitis following skin exposure: dry, cracked and erythematous skin
- Neurobehavioral dysfunction: above plus short-term memory loss, difficult concentrating, decreased attention span, neurobehavioral test abnormalities, cerebral atrophy, EEG abnormalities (diffuse slow waves)

The severity of responses and damage depends on the amount of exposure, individual susceptibility, and other factors. The route of exposure (inhalation, ingestion, skin contact) is important for some effects because many fuel ingredients are irritants. Irritation of the part of the body where exposure occurs is likely if there is sufficient exposure. That is why inhalation can cause coughing, a sore throat and nose and aggravation of many respiratory conditions (as discussed below). Likewise skin exposure can cause skin damage and aggravation of pre-existing skin conditions.

The chemicals discussed below and many other fuel ingredients are solvents that can pass through the skin and circulate throughout the body. Many easily evaporate into air so their presence on land, materials or water poses a health risk due to both skin contact and inhalation of airborne toxic chemicals as discussed in the "Exposure" section.

The 1999 CDC Toxicological Profile for Total Petroleum Hydrocarbons (TPH) provides some useful information fuels (CDC, 1999). However, it is now very out of date, so should be relied on with considerable care, and with attention to extensive new scientific information produced over the last 15 years since the scientific data for this document was collected. New medical scientific information on the toxicity of fuels and their ingredients is generated frequently. A study released in November 2012 by Sekkal et al is an example of this, finding that "Even low exposure to petroleum-derived hydrocarbons is associated with more respiratory and nasal symptoms, lower pulmonary function, and airway inflammation." (Sekkal et al, 2012)

Chemicals in fuels are considered petroleum distillates, a category that posses serious respiratory hazards when it is inhaled as a mist. This is unlikely during flooding but could conceivably occur. When such inhaled in large quantities as a mist these chemicals can coat the lungs. They aren't always removed adequately by the body, and that can result in serious lung irritation and chemical pneumonitis. This requires rapid medical attention.

Oils as a broad category are associated with health effects that are not discussed here. For example, oil acne (folliculitis) can be caused by heavy exposure to oil, especially oil-soaked clothing (LaDou, 2007).

It is beyond the scope of this webpage to list all of the potential impacts that may be seen following exposure to hydrocarbon fuels. Readers can obtain additional information from sources listed in the Additional Information section. This may be updated as new information becomes available.

Acute versus Chronic Exposure Hazards - Although chronic (long term) exposure health effects are described separately in many cases, individual responses to short or long term exposures vary considerably. Moderate or low level exposures of susceptible individuals such as children and those with health problems can cause health effects usually associated with high exposures. Acute exposure effects do not predict the likelihood or severity of effects that may occur following longer-term low level exposures.

Due to the presence of benzene and other chemicals that can cause DNA damage and mutations, both acute and chronic exposure can result in serious health risks. There is no completely safe level of exposure. We have mechanisms to repair DNA damage, but they are not always successful. Additional details are provided in US EPA's cancer risk guidance document at (http://www.epa.gov/riskassessment/guidance.htm) Reducing exposure reduces cancer risks and the potential for other types of harm.

Health Hazards of Specific Fuel Chemical Ingredients

The information below on specific chemical ingredients provides additional detail on some of the health consequences that can occur. The following information is based on CDC's Toxicological profiles cited for each chemical, unless other sources are listed. These profiles are summaries of the toxicological, epidemiological, and other medical scientific studies that provide information on damage that may be caused by exposure to these chemicals. Also see sources in Additional Information.

Benzene

Benzene is an extensively studied ingredient of gasoline, diesel and other fuels. A detailed review the toxic effects and other characteristics of benzene is available from the Centers for Disease Control (CDC) at: http://www.atsdr.cdc.gov/toxprofiles/tp3.pdf and many additional resources are available at: http://www.cdc.gov/niosh/topics/benzene/ The information below relies on the CDC sources unless otherwise noted.

Benzene is of high concern because it can cause a wide range of toxic effects and is also carcinogenic and mutagenic. Damage can occur at low levels of exposure following both short term and long term exposures.

Benzene is a solvent that can pass through the skin and circulate throughout the body. It is volatile, meaning it can easily evaporate from water into air. It's presence in water or on land or materials poses a health risk due to both skin contact and inhalation of airborne benzene. This is discussed in more detail in the "Exposure" section.

High levels of exposure to benzene can cause ventricular fibrillation, congestive and toxic gastritis, pyloric stenosis, myalgia, kidney damage, skin irritation and burns, swelling and edema, vascular congestion in the brain, and central nervous system depression.

The effects listed above under the section titled "Common Health Effects of Hydrocarbon in Fuels can all result from exposure to benzene. The following are most noteworthy:

Benzene is a respiratory irritant and airborne benzene can cause eye, nose and throat irritation. In people with asthma, COPD, or other respiratory conditions, the irritant properties of benzene may aggravate their symptoms. The level of exposure at which respiratory irritation will occur varies based on individual susceptibility and the severity of their respiratory health condition.

Skin contact does not cause immediate burns, but can lead to skin damage, especially in people with pre-existing skin conditions or fragile skin (e.g., infants). People can experience redness, dryness, cracking (dermatitis) and other skin disorders due to the solvent properties of benzene (http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/benzene/health_ben.html)

Lower level exposures can cause a lesser degree of central nervous system depression that may be manifest as headaches, nausea, dizziness, confusion, tiredness, and cause other neurocognitive problems.

Long term (chronic) exposures to benzene have also caused peripheral nervous system abnormalities and distal neuropathy which can appear as numbness, tingling, and lack of control of muscles in the hands and feet. Chronic exposures have also caused difficulty sleeping, and

memory loss. Benzene exposure can cause aplastic anemia, a potentially life-threatening disease that can lead to fibrosis and may be a precursor of leukemia.

Benzene can damage the immune system and cause abnormal development of blood cells. When blood cells are deficient, this can cause other serious medical conditions, including infection due to a lack of leukocytes and increased cardiac stress due to a lack of erythrocytes.

Animal studies of benzene found endometrial polyps and ovarian lesions (female reproductive system abnormalities) in females exposed for two years, and preputial gland lesions (reproductive system abnormalities) in males. There is also evidence that benzene can cause harm to the fetus, and reduce fertility. Benzene can cause chromosomal abnormalities in lymphocytes and bone marrow cells.

Due to its toxicity and its status as a known human carcinogen, federal benzene exposure limits are low. The US EPA's Maximum Contaminant Level Goal for benzene in drinking water is zero because any amount of exposure may pose some cancer risk. Benzene in air above 0.04 parts per billion can generate a substantial cancer risk, based on EPA's de minimis risk of one in one million cancer cases (www.epa.gov/ttn/atw/hlthef/benzene.html) Note that this limit is for benzene alone, and doesn't consider other chemicals present in gasoline a fuel.

If other carcinogenic chemicals are present, the amounts of each must be reduced to stay below a threshold risk of one in one million. It is not necessary to accept a risk of one in one million. That is an arbitrary value used for policy decisions and rulemaking. Individuals can further reduce their cancer risk by avoiding exposures to levels lower than those specified by federal regulations.

Added risk

Benzene exposure in combination with alcohol increases the harm to blood cells. Exposure to toluene, another gasoline ingredient (discussed below) also increases the toxicity of benzene because toluene competes with benzene for the metabolic pathways that break down benzene.

Safety can't be determined by smell for benzene and many other toxic chemicals. The odor threshold for benzene is 1,500 ppb (US EPA, 2002). This is more than 37,000 times higher than the level of 0.04 parts per billion listed above.

Xylenes

The toxicity of the three chemical isomers of xylene (referred to here as "xylenes", was reviewed by CDC-ATSDR in a 2007 Toxicological Profile (http://www.atsdr.cdc.gov/toxprofiles/tp71.html#bookmark06). Xylenes exist in three forms: the ortho, meta, and para isomers. Each has slightly different toxicological properties. See the Toxicological Profile for additional details on this if information on specific isomers is important.

Xylenes are solvents that can pass through the skin and circulate throughout the body. They are volatile, meaning they can easily move from water into air. Their presence in water or on land or materials poses a health risk due to both skin contact and inhalation of airborne xylenes. This is discussed in more detail in the "Exposure" section.

The effects listed above under the section titled "Common Health Effects of Hydrocarbon in Fuels can all result from exposure to xylene. The following are most noteworthy:

Skin exposure to xylene can cause irritation and poses special risks to people with skin conditions or sensitive skin, such as babies. Skin exposures to xylenes have caused irritation, dryness and scaling, vasodilation, and possibly contact urticaria in people.

Xylenes are respiratory irritants and airborne exposure can cause eye, nose and throat irritation. In people with asthma, COPD, or other respiratory conditions, the irritant properties may aggravate their symptoms. The level of exposure at which respiratory irritation will occur varies based on individual susceptibility and the severity of their respiratory health condition.

Xylenes can alter central nervous system function in people, resulting in loss of memory and concentration, headaches, dizziness, nausea, vomiting, and anxiety. High exposure levels can lead to unconsciousness, amnesia, brain hemorrhage, and seizures.

Xylenes cause some types of nervous system disruption and damage that are not commonly encountered. They can cause both hyper- and hypoactivity in short term animal studies (it is biphasic). With longer term exposures, hyperactivity was routinely observed, but so were periods of hypoactivity. The para isomer of xylene caused a significant loss of hearing in a specific frequency range in animals (10 - 25 kHz). No reports of human hearing loss were given in the CDC document.

Liver and kidney damage have been reported in workers exposed to xylenes and in animal studies. These types of effects are often not immediately noticed. If high exposure have occurred, medical care providers should be alerted so they can evaluate whether damage has also occurred. Some common evaluation options are listed in the “Clinical Information” section below.

Effects of xylene during prenatal development were studied in animals. Xylene caused nervous system damage, as indicated by impaired performance on physical tests. It also caused delayed bone formation, and reduced fetal weight. Some of these effects may be due to maternal toxicity, but all are worth consideration due to the serious nature of the effects.

There is no evidence from human or animal studies that xylenes cause cancer. The International Agency for Research on Cancer and the US EPA determined that xylene could not be classified regarding carcinogenicity in humans due to a lack of evidence.

Xylenes cause many of the same health problems that benzene causes. The presence of xylenes and other similarly acting chemicals in gasoline pose health risks for many systems in the body, and exposure should be avoided whenever possible.

Toluene

Toluene was evaluated by the CDC-ATSDR in 2000, as reported in a Toxicological Profile (http://www.atsdr.cdc.gov/toxprofiles/tp56.html).[2]

Toluene is a solvent that can pass through the skin and circulate throughout the body. It is volatile, meaning it can easily move from water into air. It’s presence in water or on land or materials poses a health risk due to both skin contact and inhalation of airborne toluene. This is discussed in more detail in the “Exposure” section.

[2] Additional information on toluene, including an updated literature review, is available on request if contaminations levels are severe.

The effects listed above under the section titled “Common Health Effects of Hydrocarbon in Fuels can all result from exposure to toluene. The following are most noteworthy:

Skin exposure can cause irritation and poses special risks to people with skin conditions or sensitive skin, such as babies. Some effects observed with exposure to toluene include dryness and scaling, dermatitis, redness and soreness of the skin.

Toluene is a respiratory irritant and can cause eye, nose and throat irritation. In people with asthma, COPD, or other respiratory conditions, the irritant properties may aggravate their symptoms. The level of exposure at which respiratory irritation will occur varies based on individual susceptibility and the severity of their respiratory health condition.

Toluene can alter central nervous system function in people, resulting in loss of memory and concentration, headaches, dizziness, nausea, vomiting, fatigue, and anxiety. High exposure levels can lead to unconsciousness, amnesia, brain hemorrhage, and seizures.

Toluene is unusual in its ability to also cause the loss of some sensory abilities, such as color vision and hearing acuity. Aspirin and acetaminophen (e.g., Tylenol) can increase hearing loss caused by toluene. It is important to be aware of this if you are using these medications. People should consult their physicians about any questions they have on taking these medications while in areas of contamination or working with contaminated materials.

Long term human exposure to toluene has caused permanent damage to the brain, leading to impaired speech vision, hearing, memory loss, poor balance, loss of muscle control, and a decline in mental abilities.

In workers who were exposed to toluene, there was an increase in cardiac abnormalities in the electrical conduction of the heart.

Toluene exposure has caused abnormalities in the numbers of leukocytes, lymphocytes, and other blood cells in people. These cells are essential to normal the functioning of the cardiovascular system, immune system, and other critical systems.

Toluene may cause spontaneous abortions. Women exposed to toluene have an increased risk of having children with mental retardation and delayed growth. Similar effects were seen in studies of animals, who had evidence of permanent structural changes in the brain.

There is some human evidence that toluene causes endocrine disruption in the form of abnormal thyroid hormone levels. Thyroid function disruptions can cause a range of health problems in adults. When it occurs in pregnant women, it can cause damage to the fetus causing retardation. It can impair the ability to have children.

Studies in animals support the observations of health damage in people. Animal studies involving long term exposure to toluene found that it caused kidney and liver damage, damage to the blood forming system, a decrease in red blood cells, cardiac abnormalities, immune system damage and central nervous system damage.

Toluene studied in animals has caused increased testicular weight and decreased sperm count. This has implications for the human male reproductive system and indicates that toluene may damage male fertility.

The EPA, and IARC have not classified toluene regarding its potential to cause cancer. An updated scientific literature review on toluene is available via request from the authors, if contamination by toluene is severe.

Fuel Additives

Fuel additives vary depending on the type of fuel. They may be used to increase oxygenation, decrease corrosion, or for other purposes. There are dozens of fuel additives and some are very toxic. For example, the fuel additive MTBE that was used in gasoline during the 1990s remains in use as an additive in some marine fuels. Consequently it may be a contaminant in areas where marine fuel spills have occurred as a result of flooding or other disasters. Because it is both an ether and a solvent, it is associated with a wide range of potential health hazards. Numerous studies in animals exposed through air or water have found caused many types of cancer (Burns and Melnick, 2012). The presence of additives in fuels, which are usually not disclosed by suppliers is another reason to avoid exposure to fuels contaminated water, air land, and materials.

Mixtures of Chemicals

People are likely to be exposed to multiple products if they are in an area where fuel contamination reaches water or land. Exposure to multiple chemicals can increase the severity of health problems, since many have toxic effects on the same organs in the body. An article on chemical mixtures by Dr. David Carpenter, Director of the Environmental Institute at the State University of New York in Albany discusses this problem and provides additional sources of information (see listing in the bibliography contained in the Additional Information section).

US EPA provides information on health hazards of chemical mixtures and requires special consideration of the health effects of mixtures in situations where mixtures are often encountered (e.g., hazardous waste sites). Information on mixtures can be obtained through a search of US EPA's website at: www.epa.gov

The authors reserve the right to update or correct the information on the toxicity of fuels and their ingredients as new evidence becomes available.

CLINICAL INFORMATION

The following does not constitute medical advice and should not be construed as patient care in an individual presentation. It offers information on initial steps in a non- emergency room setting. People must obtain specific medical guidance from their personal medical care provider.

Numerous federal government websites and textbooks focus on occupational environmental medicine, providing guidance on managing exposures to chemicals. ATSDR, a part of the CDC, provides the following medical management guidelines that are relevant to fuels exposure:

Gasoline: http://www.atsdr.cdc.gov/mmg/mmg.asp?id=465&tid=83

and two of its ingredients:

Toluene: http://www.atsdr.cdc.gov/MMG/MMG.asp?id=157&tid=29

Xylene: http://www.atsdr.cdc.gov/MMG/MMG.asp?id=291&tid=53

According to ATSDR, "these provide the following basic chemical and exposure information

- a summary of potential health effects,
- prehospital management information,
- emergency department management information, and
- information for the patient. "

(http://www.atsdr.cdc.gov/MMG/index.asp accessed 11/5/2012)

Gasoline is similar in many respects to diesel and other hydrocarbon-based fuels. As previously noted, they share many of the same toxic ingredients. There are patterns of responses that are anticipated following exposure. However, as previously noted, individual responses vary greatly.

It is important to evaluate a patient based on the potential for exposure and harm. Virtually every organ system can be damaged by fuels exposure, with the degree of harm related to the amount and route of exposure as well as other factors:

- respiratory system
- nervous system, including the brain & sensory systems
- liver reproductive/urogenital system
- kidneys
- endocrine system & metabolism
- circulatory system
- gastrointestinal system
- immune system
- musculoskeletal system
- hematopoietic system
- skin and integumentary system

Damaging or altering these systems causes a wide range of diseases and conditions. Individuals with pre-existing conditions or susceptibilities in these systems are at higher risk. In addition, interference with normal growth and development through endocrine disruption and direct damage to fetal tissue is caused by many fuel ingredients (CDC, 1999). DNA damage resulting from exposure to benzene can cause cancer and multi-generational birth defects.

Dr. Michael Harbut, director of the Environmental Cancer Program at the Karmanos Cancer Institute in Detroit, Michigan summarized steps that are taken when patients are initially seen in his clinic following a suspected or known exposure to fuels.

An exposure history directed toward times and places of exposure and a characterization of exposures should be obtained. The guide to Taking an Exposure History by ATSDR/CDC can be very helpful: http://www.atsdr.cdc.gov/csem/exphistory/ehexposure_form.html.

Standard diagnostic procedures and tests can be relied on to evaluate many of the potential impacts of fuel exposures. These include:

- a standard physical exam with special attention to the skin, respiratory system and neurological responses
- a standard blood panel with CBC differential
- a standard tests of kidney and liver function

Testing should, of course, depend on the individual clinical presentation, but often includes establishing a baseline to which future hematologic and other possibly mutagenic and/or carcinogenic indicators may be compared.

In addition, **persons presenting with applicable signs or symptoms of exposures** would, at a minimum, receive the following:

- complete pulmonary function testing, including diffusion capacity\
- gamma-glutamyltransferase
- beta-2 microglobulin\
- a complete blood count
- serum protein electrophoresis with immunofixation
- urinalysis
- antihistamine antibody
- a mental status examination
- a minimum of a chest x-ray and if pertinent abnormalities are found on the radiographs or other applicable studies, a high-resolution CT on the 64 slice unit

Treatment decisions should be based on clinical presentation and objective evidence and usually do not vary from non-toxin induced presentations of the same condition, with the exception of cancer surveillance.

Pregnancy presents additional concerns to the mother and the fetus who may be at greater risk of birth abnormality or harm resulting from mutagenic and carcinogenic exposures.

Regarding biomonitoring, according to Dr. Harbut there is no readily available clinical blood test proven to be broadly reliable. Furthermore, obtaining these levels is of unclear clinical significance. Although biomonitoring is possible for some chemicals, benzene and toluene

levels are highly variable and these chemicals are rapidly metabolized and eliminated form the body (LaDou, 2007).

A Curbside Consult" explaining some clinical issues in more detail was developed by Dr. Harbut regarding oil exposure. It is generally relevant to fuels exposure and is available in two formats: Audio (mp3) (22 minutes, 10 MB) and Video (wmv) (22 minutes, 170 MB). It includes information on chemical pneumonitis and other conditions that are not commonly encountered by medical professionals unless they are dealing with chemically-exposed workers or members of the general public.

All urgent care requirements should be directed to a personal physician or an emergency room.

- Questions from physicians treating patients may be directed to Dr. Michael Harbut through Cynthia Noraian at noraianc@karmanos.org or during business hours at: 313-578-4282.

- The New Jersey Clinical Center for Occupational and Environmental Health has numerous specialists in this field and is located at 170 Frelinghuysen Road in Piscataway. Phone: (732) 445-0123

- Occupational and environmental clinics specialize in the diagnosis and treatment of chemically-exposed patients. See http://www.aoec.org/ for clinic locations by state.

SUSCEPTIBLE POPULATIONS

Whether health damage occurs depends on many factors, including the amount, nature and timing of exposure, individual health status, other toxic exposures at work or home, and basic inherited susceptibility. Taking such factors into account, there are some populations that are generally more susceptible and require special consideration. The National Library of Medicine provides **information on special populations in disasters is at:**
http://disasterinfo.nlm.nih.gov/outreach/specialpopulationsanddisasters.html

Children are especially vulnerable to toxic chemicals that disrupt normal growth and development. Their brains are highly susceptible to many neurotoxic ingredients, according to pediatricians and scientists who evaluate susceptibilities during childhood. They have urged substantial caution and efforts to protect children from exposure to neurotoxic chemicals (Grandjean et al, 2007).

Chemicals that can cause endocrine disruption (abnormal hormone levels) are also of high concern. Many fuel ingredients have demonstrated the capacity to alter the levels of hormones in the body. Endocrine disruption cause abnormal growth, infertility, and other health conditions. Careful regulation of hormone function by the body is essential for normal growth and development of all aspects of the body. These include brain development, height, weight, age at which sexual maturation occurs, and other fundamental benchmarks of healthy growth

Children's exposures may be higher than adults and can include contaminated soil or sand, which aren't commonly a major exposure route for adults. Playing in contaminated areas can

result in ingestion of contaminated soil and sand, and their proximity to the ground makes them more likely to inhale these materials.

Newborns are especially vulnerable due to incompletely formed immune and detoxification systems. They also have a much greater vulnerability to contaminants that come in contact with their skin (e.g., via contaminated bath water). Infants have an incompletely formed skin barrier when they are born, and so can absorb chemicals such as solvents much more readily. They also have a larger skin area in relation to their overall weight and ability to detoxify chemicals. This also increases the amount of a chemical they can absorb during bathing, which is generally greater than that of adults.

A number of journal articles and other sources that discuss children's greater susceptibility to toxic chemicals are listed in Additional information.

The developing fetus is susceptible to toxic effects of many fuel ingredients that can cause mutations, endocrine disruption, skeletal deformities, neuorocognitive damage, and other types of damage. Systems at risk vary over the course of the pregnancy. Most chemicals circulating in the mother can pass through the placenta and reach a baby so care should be taken to avoid exposure and consult a prenatal health care specialist regarding appropriate protections.

All of the concerns expressed above regarding greater susceptibility during childhood are relevant to children during the fetal development period. In addition, chemicals in fuels that reach the mothers circulation as a result of her exposure will circulate in her bloodstream. Consequently, they reach the fetus directly, and also can result in elevated levels of these chemicals in the amniotic fluid that the baby is growing in.

Pregnancy places increased stress on many maternal organ systems, including the liver, kidneys, and cardiovascular system. Fuel ingredients that are toxic to these systems can pose serious health risks. Most women are advised to consumer more water during pregnancy, and so contaminated water is of special concern.

Pregnancy also requires a careful balance of maternal hormones to maintain a health pregnancy. Endocrine disruptors in fuels can jeopardize that balance. Some alterations can have serious consequences for cognitive development (e.g., reduced thyroid function).

Women carrying multiple babies are at especially high risk due to their higher stresses on kidney function and other systems.

People with medical conditions are often more susceptible because chemical ingredients can damage already-impaired systems in the body. For example: inhalation of gasoline, an irritant, poses risks for those with asthma and other respiratory conditions such as COPD. As discussed below, the extensive neurotoxic effects of fuel ingredients can create health problems for people who have neurocognitive conditions such as ADHD. Fuel ingredients can damage most organ systems, so people with health conditions should consult their MDs regarding their susceptibility if they will spend time in contaminated areas.

People taking medications may have a reduced ability to detoxify toxic chemicals. Overall, the actions of the kidney and liver that are required to detoxify fuel chemicals can cause competition between the toxic chemicals and essential medications for the capacity of the liver and kidneys

to process medications. This can also result in changes in the potency of medications, causing increased or decreased potency.

A medical care provider and/or pharmacist, possibly in consultation with a toxicologist or OEM physician, can assist people in understanding this and making any adjustments that are necessary. An example of this previously noted under "Health Effects" is that exposure to toluene, a common ingredient in gasoline, can pose a greater health risk in people who are taking aspirin or acetaminophen. In some cases, it may be necessary to stay away from the contamination to insure that medical conditions requiring careful management of pharmaceutical balances in the body are not disrupted.

People with neurocognitive challenges are subjected to generalized nervous system stresses in disasters. In addition, many fuel chemicals are neurotoxic and can alter nervous system function, especially in the central nervous system (the brain). Exposure to neurotoxic chemicals poses health risks for those with ADD, ADHD, Asperger's, Alzheimer's and other neurocognitive and neurobehavioral challenges. Appropriately trained medical care providers must evaluate any impacts and consider adjusting management strategies as needed.

People exposed to other toxic chemicals or working with hazardous materials or situations at work or home may be at higher risk. If their systems are already detoxifying chemicals they routinely encounter, they may have less capacity to metabolize additional chemicals that they are exposed to. Due to the neurotoxic effects of fuels, special attention must be paid to any changes in cognitive abilities (e.g., attention, balance) to avoid harm during work in any hazardous situations on the job, during repairs or demolition after disasters, or in other activities.

PUBLIC HEALTH ACTIONS

Due to the types of harm that can be caused by exposure to chemicals in fuels, exposure should always be minimized. Chemicals such as benzene impose some degree of health risk with any exposure as discussed in the "health effects" section. Public health agencies at the state, local and federal levels need to provide comprehensive information to the public, responders, medical care providers, and all other parties that are involved in addressing flooding and disasters that involve exposure to toxic chemicals such as fuels.

Considerable information is provided on some government websites (see listings in Additional Information. Others are very general, lacking any information on toxic chemicals, how to avoid them or obtain assistance if exposure has occurred. The public can request that agencies be more responsive in providing essential information.

It is especially critical to identify people who need higher levels of protections than the average healthy adult. "Susceptible populations" discussed above , must be considered. Whether someone should remain in a contaminated area should be determined through consultation a person's physician, possibly in consultation with specialists in occupational and environmental medicine (OEM). Occupational and environmental clinics specialize in the diagnosis and treatment of chemically-exposed patients and have MDs with board certification in OEM. See http://www.aoec.org/ for clinics in each state.

Based on discussions with Dr. Kenneth Rudo, the North Carolina State Toxicologist who has dealt with fuel contamination incidents for more than 20 years, inhalation and dermal exposures

to elevated levels of petroleum products in flood waters may pose increased health risks, including cancer. In his capacity advising emergency response and other parts of the health department, Dr. Rudo cautions that if there are noticeable inhalation or dermal effects as described above, people should seek medical treatment immediately. If the treating physician needs more information about how to diagnose and treat petroleum related exposures and health effects, they can contact an OEM clinic.

The New York State Department of Health provides guidance on residential oil spills and flooding. Regarding the cleanup, they offer the following useful information:

"Some oil-coated materials can be difficult to clean.

- Hard-surfaces, such as glass or metal, can be cleaned with detergents or other cleaners.
- Porous materials such as wood, boxes, fabrics, sheetrock or insulation will most likely need to be discarded.
- Remove contaminated items and materials to the outside of the home.
- Stockpile discarded materials on plastic and cover with plastic.
- Use cat litter or other absorbent materials available at home improvement stores to absorb any remaining oil.
- Check with a professional cleaning company for information on cleaning or deodorizing household furnishings.

When performing any cleanup work you should take steps to minimize exposure.

- Wear clothing that will help reduce skin exposure, such as long pants, long sleeve shirts and gloves (check on appropriate materials for these below).
- Work in areas that have been ventilated, as described above.

Individuals with questions about the disposal of:

- flood-related, petroleum-contaminated debris or household hazardous waste should call NYSDEC at 518-402-8678
- non-residential waste should call NYSDEC at 518-402-8792

(Source: http://www.health.ny.gov/environmental/indoors/air/oil_spill_flood.htm)

Dr. Michael Harbut has treated people exposed to fuels for more than 25 years as the director of an occupational and environmental health clinic in Michigan. He also emphasizes prevention of exposure to protect health. Sound public health practices require that both medical personnel and the public be informed about health risks and how to minimize those risks. Medical personnel also require access to sources of additional information to address the specific needs of individuals who have been exposed and/or have symptoms that may be related to exposure. The CDC provides generalized guidance on medical management of exposure to gasoline and two of its ingredients, as listed in the "Clinical Information" section.

A 2007 report from the World Health Organization found that as much as 24% of global disease is caused by environmental exposures that could be averted. They also found "the environment significantly affects more than 80% of (these) major diseases" including cancer, cardiovascular diseases, etc. (WHO, 2007).

Specifically focusing on a North American report on children's health and environmental indicators, the importance of exposure to toxic substances was highlighted (WHO, 2006). Avoiding exposures to toxic chemicals in hydrocarbon fuels is an important public protection strategy to reduce the future burden of disease and death.

EXPOSURE

Exposure to the chemical ingredients in fuels can occur when people handle or clean up contaminated materials, when they inhale contaminated air, or ingest contaminated water or food. People have some control over exposures during cleanup, but may not be aware of what they are handling or breathing. People are also exposed involuntarily when they live, work, attend school or otherwise are in a contaminated area.

Fuels release chemicals into air from any contaminated media – water, land, building materials, etc. The chemicals are inhaled by those in vicinity. This can occur from gasoline, diesel or other fuels over an extended period of time. Depending on the amount of contamination, levels of airborne benzene and other fuel ingredients can be hazardous. Some people are much more susceptible than others, and should be afforded more protection (see "Susceptible Populations").

Exposure to toxic chemicals is not inevitable and can often be reduced or prevented. Understanding how exposure occurs enables people to make decisions regarding their actions and potential health risks. When avoiding exposure isn't possible, there are options to reduce the amount of exposure. These come largely from the field of occupational health and safety, and are useful for the general public when their communities are contaminated with chemical hazards.

Types of Exposure

Most fuels contain a combination of many chemical ingredients with various physical properties. These can cause many different types of exposure. Since the way people are exposed can determine the nature and degree of harm, it is important to be aware of how you can be exposed to fuels following a flood or other disaster.

Airborne Exposure - Some ingredients quickly evaporate and become airborne, while others will remain on land and water for an extended period of time and can persist for years. Airborne chemicals cause exposure of everyone in the vicinity of these fuels unless they have a highly effective respirator or an alternative air supply. that does not have a respirator. Once fuel chemicals are inhaled, they are rapidly diffused from the lungs into the blood stream and circulate throughout the body.

Elevated levels of benzene, toluene, and other volatile toxic chemicals are commonly found in the air where gasoline has been spilled. Some volatile organic chemicals (VOCs) can be detectable by smell. But not all hazardous airborne chemicals have a detectable odor. The absence of odors is not an indication of safety. As previously noted for benzene, the "odor threshold" for many toxic chemicals is much higher than the level at which harm can occur.

Skin Contact - Many fuels have solvent properties and are able to penetrate the skin. As a result of this, skin exposure also results in fuel chemicals circulating throughout the body. People with skin damage and infants who have incompletely developed skin layers will experience more absorption of fuel chemicals through their skin.

Ingestion - While people don't intentionally ingest contaminated water or food, it can occur if they aren't aware of its presence or don't realize that it poses a health risk.

Contaminated tap water is of special concern for infants who consume formula mixed with water (e.g., powder or concentrate) because every meal that they have will contain whatever contaminants are in the tap water of the home. Other people at higher risk when water is contaminated include those who need to consume more water for medical reasons (e.g., pregnant women & those with many medical conditions), people working in hot, dry, or strenuous conditions who typically drink more water, and adults and children who engage in athletic and other activities that require drinking more water.

Contaminated tap water is also generally of high concern when fuels are involved. The ability of toxic chemicals in fuels to move from water into air means that any use of water will result in the release of those chemicals into the air. Shower and bathing, doing the dishes and laundry, washing the floor, and other activities with water all result in the release of benzene, toluene, xylene and other similar chemicals in fuels being released into the indoor environment.

Conditions that cause an increase in the release of these chemicals from water include heat (as in cooking, showering and bathing) , agitation (e.g. doing the laundry), dry conditions in the home, and some other activities. Other conditions that cause the release of more chemicals from water are discussed in publications on exposure listed in the Additional Information section.

Exposure to these and other airborne chemicals in homes following contamination from tap water is a well-established health concern, and considerable care should be taken to avoid exposure as a result of this. Increasing ventilation through bringing in outside air will reduce the levels, but is not practical in many situations due to weather conditions. Some home water filters are effective in reducing the amounts of fuel chemicals in water.

Ingestion can also occur when people unintentionally consume dust or sand. This is primarily a concern for children. When flood-contaminated soil and sand dries, it can create chemically-contaminated dust that contains chemicals that can be inhaled or ingested, especially by young children who are playing in or on contaminated soil. It can also be tracked into homes and blow into homes on windy days.

Many fuel contaminants will move into the air quickly enough that they will not be present over a growing season. However, persistent contaminants in garden soil can be taken up by plants and cause exposure through food grown locally. If there is any doubt about contamination in

soil that is being used to grow food, testing should be carried out to determine what is present and if it poses health risks.

Legacy - Over time, the amount of chemicals in water and in the residue that is left on land and property will decrease. Chemicals that don't readily evaporate or break down can persist for an extended time. Their persistence depends on the specific characteristics of each chemical and the environment that they are present in (e.g., soil, sand, water). Other factors including temperature, the presence of bacteria that can break down hydrocarbons, sunlight, saltwater, and other features unique to each environment will impact how long chemicals remain. Some fuel chemicals can remain for years in the soil and other materials. This is especially true of chemicals that don't evaporate into the air or easily break down during normal environmental processes.

Cleaning Agents & Other Chemical Treatments Following Fuel Spills – Many cleaning agents are highly effective and not toxic, but there are also a number of products that are routinely used by consumers that require considerable care. Bleach is an obvious example, because it is widely known to cause skin burns, eye irritation as it evaporates, and sever damage if ingested. It is provided with a safety cap and extensive warning labels. Many toxic cleaning products don't have the same degree of protection or public awareness.

It is beyond the scope of this website to describe cleaning products and their properties. However, consumers and workers are urged to read labels carefully and take all precautions advised by the manufacturers. If cleaning agents appear irritating to the nose or eyes, use as much ventilation as possible. In addition, some cleaning products can create a toxic gas when they are mixed together. All label instructions must be followed.

It is generally useful to consider all available personal protective equipment, including those described below, when cleaning fuel contamination because exposure will occur to both the fuel itself and ingredients in the cleaning agent.

When in doubt, consult medical professionals if you are concerned about the safety of a product, have any health concerns, or experience any health symptoms. This does not constitute medical advice about cleaning products, which must be obtained from your personal physician.

There have been anecdotal news reports of the use of dispersants following Hurricane Sandy. Chemicals in dispersants and other strong industrial chemicals used following spills pose additional potential health risks. Anyone working with non-standard cleaning agents should request and carefully review the Material Safety Data Sheet MSDS that is available for each product.

Employees have a legal right to the MSDS for all chemicals that they handle on the job.

Most companies also make these available online for all of their products, enabling the general public to have has access to information such as chemical ingredients, hazards, government guidance on exposure limits, and safety measures. It is important to keep in mind that these are usually prepared by or sponsored by the manufacturer, and they determine the content to some degree. They may list many ingredients are proprietary (confidential) and so not disclose chemical ingredients that may be of considerable interest from a health perspective.

An MSDS for a product can often be retrieved by "Googling" the product name and the term "MSDS". Information on an MSDS does not replace information from a person's physician, but can supplement it. It often includes guidance on personal protective equipment that is required to work with a product. It may contain information that raises questions a user should pose to their personal physician before using a product.

PERSONAL PROTECTION FROM EXPOSURE

Those people who are working with or close to contamination should consider using personal protective equipment based on the amount of exposure they are likely to have, and whether they are at risk for coming into direct contact with contaminated media. Inhaling high levels of fuels poses immediate health risks, as does skin exposure to concentrated media, depending on the duration of exposure. In all cases the best health option is to avoid areas that are contaminated. Respiratory and skin protection are discussed below because that is not always possible.

This section contains very brief information on personal protection. It is highly recommended that anyone dealing with hazardous materials review the detailed information is available in Additional Information that contains recommendations from many agencies and organizations with expertise in this area. When possible, obtain professional "in person" guidance on personal protection.

Workers who clean up potentially hazardous materials, contaminated water or otherwise put themselves in harms way for their employers are required by law to receive specialized training to minimize the harm they experience. That training must include information on the hazards and on the best ways to protect themselves, including work strategies and personal protective clothing and equipment.

The type of protection needed depends on what is present in the air, water, soil, or debris. For example, plastic bags that are often used by people following floods to protect their legs can protect against some waterborne bacteria, but cannot protect skin from many fuels and other chemicals. The presence of chemicals in water means that they may be present in air, but that often can't be quickly determined after disasters. It is always safest to void contact and avoid breathing air in areas that may be contaminated.

According to OSHA: "If water is suspected of being contaminated with hazardous chemicals, cleanup workers may need to wear special chemical resistant outer clothing and protective goggles. Before entering a contaminated area that has been flooded, you should don plastic or rubber gloves, boots, and other protective clothing needed to avoid contact with floodwater." (http://www.osha.gov/OshDoc/data_Hurricane_Facts/floodcleanup.pdf)

No personal protective equipment is foolproof. If you feel ill, especially if you were exposed to toxic chemicals, bacteria, asbestos, or other hazards, seek medical attention.

The following information is a very basic description of some options for personal protection. It does not provide all of the details required for working around hazardous chemicals or materials. The Additional Information section provides links to many resources on this topic from OSHA and other sources. In addition, many locations that sell protective clothing and

equipment have multiple types of equipment with information on the packaging that specifies what it is suitable for. Since materials vary greatly in their ability to prevent exposure to chemicals in fuels, it is critical to obtain equipment and clothing made of materials designed for use around aromatic and aliphatic hydrocarbon solvents (e.g., benzene in fuel). If you are working around other chemicals or materials, determine what hazards exist so that you can protect yourself to the degree possible from exposure and harm.

Most protective equipment and products have detailed information in the packaging and additional resources online to guide users in how to wear the items, when cartridges and other elements need to be changed and provide other critical information. Since many members of the general public who will be involved in cleanup do not have experience with these products and may not have access to assistance from professional industrial hygienists, it is very important to review the information provided by product manufacturers, online sources, and local guidance in order to minimize exposure and harm.

Respiratory Protection

There are many types of respiratory protection and they vary greatly in their ability to protect people. All must fit tightly to the face or contaminated air can enter around the mask. The "seal" around the face is critical, and a good seal can't be obtained if someone has facial hair (e.g., a beard). A health and safety professional can advise on how to do seal checking and fit testing, which are both important to insure the mask is working and reduce exposures to hazardous materials.

In dusty environments, the masks or cartridges must be checked frequently and may clog or become saturated with chemicals. Some areas may have asbestos or plaster dust, which can be very dangerous. They are not discussed on this website but details are available on other websites listed in Additional Information.

Caution

Wearing a respiratory that fits properly may make it more difficult to breathe because air must be pulled through the mask material or cartridge. This can pose risks to people who have respiratory difficulty, heart problems, or circulatory problems. Check with your personal physician to determine if you have any health conditions that may make it inadvisable for you to use respiratory protection.

OSHA's technical links on respiratory protection are complex and are available at:
http://www.osha.gov/SLTC/respiratoryprotection/guidance.html

Small paper masks that are fit by bending a metal strip against the nose are the simplest type of respiratory protection. They don't usually fit snugly against the face, and are primarily used to reduce exposure to dust and other large particles (i.e., "dust masks"). These do not protect against chemical exposures such as those resulting from fuels.

Some paper masks are impregnated with charcoal and are able to reduce exposure to some chemicals. They will be labeled NIOSH approved N-95 respirators. They are designed for one time use and are disposable.

Both of these types of masks are available at hardware and home improvement stores and are inexpensive. They must be fit tightly against the face or contaminated air will be inhaled. In dusty environments they must be changed regularly.

Masks with cartridges may provide more filtration, usually via charcoal in the cartridge. They may be called N95 Filtering Face-piece Respirators" and are usually made of rubber or elastomeric material. They look like what is called a "gas mask" in the movies.

Chose a cartridge that is specifically designed to reduce chemical vapors , stating that it can remove organic vapors or "OV". Choose a cartridge that also contains a "P100 filter", to reduce exposure to hazardous particles like asbestos or mold spores. They will also protect against dust and some will reduce exposures to mold and mildew.

These can become clogged or ineffective over time, so follow all package directions regarding when to change the cartridge/filters Half-face size are often available at hardware and home improvement stores and usually cost in the range of $20 to $30.

Other types of respiratory protection may be are more effective in substantially reducing exposure, but are more complex and expensive. Some provide air supplies and other options are available. Additional Information links to details from OSHA and other sources.

Avoidance and Ventilation Chemical ingredients in fuels are very small molecules, which is why they easily pass through or around the masks described above. That is why it's very important to avoid contaminated areas. When avoidance isn't possible, try to work in open areas that have as much clean air ventilation as possible. Ventilation of enclosed spaces is key to reducing exposure levels. Working in confined, poorly ventilated areas because vapors and gases can quickly build up to dangerous levels. When doing work in indoor contaminated areas, use fans to bring in cleaner air and to blow contaminated air out of the building.

When working outdoors, weather strongly affects chemical concentrations at ground level. Stronger winds and good convection (lack of inversions) help dilute contaminated air. Avoid working around volatile chemicals (e.g., those in fuels) when the air is still since higher chemical concentrations can accumulate. More chemical evaporation can occur immediately after a spill, when temperatures are higher, and when contaminated water is churning. Create as much ventilation as possible while working and avoid confined contaminated spaces. When possible, work upwind of contaminated areas, that is in the direction that the wind is coming from rather than blowing towards.

If you are an employee working with contamination, your employer must, by law provide and pay for personal protective equipment with training in their use. The New Jersey Work and Environment Council's hurricane website provides information on this and links to employee resources http://www.njwec.org/PDF/Factsheets/Hurricane_Resources.pdf They advise:

> "Each employer is responsible for the safety and health of its workers and for providing a safe and healthful workplace for its workers. Employers are required to protect workers from the anticipated hazards associated with the response and recovery operations that workers are likely to conduct. For additional information on Workers' Rights, Employer Responsibilities, and other services OSHA offers, visit OSHA's Compliance Assistance/Outreach Page, Workers Page and Publications.""

Additional resources for workers are listed under Additional Information.

Skin and Eye Protection

Chemicals in fuels can penetrate many types of materials, including latex, nitrile and other common materials that prevent water from reaching the skin. Fuels can also be trapped against the skin when glove material or clothing doesn't prevent skin contact. The trapped chemicals can cause even greater absorption than simple contact, and increase the risk of skin damage.

OSHA recommends **Neoprene gloves** made of synthetic rubber to protect against hydraulic fluids, gasoline, alcohols, organic acids and alkalis. Their glove recommendations are at: http://www.osha.gov/Publications/osha3151.html .

Splash goggles and clothes covering (e.g., chemically-resistant disposable suits) can reduce health risks and damage to both clothing and skin. If your skin becomes contaminated with fuels or other hazardous materials (sewage, mold, other chemicals), obtain professional advice on the best way to decontaminate it.

Goggles and face shields can be used to protect the eyes and face from floodwater splashes. Care should be taken to obtain eye protection that is designed for use in areas with fuel chemicals. Advice on eye protection is more complicated for people who wear glasses or contacts. They should consult their optometrist or ophthalmologist to obtain appropriate guidance.

See links to additional information resources on skin and eye protection in the Additional Information section.

Other Protective Actions

Many types of equipment, clothing and strategies can reduce exposure to toxic chemicals and other hazards. Additional Information contains links to many websites that have detailed information for the general public and workers regarding other options for protection.

Due to the highly variable responses of people to chemical exposures and other hazards, it is particularly important to be aware of your own responses. Many responses are dictated by individual physiology and inherited susceptibilities, so people who are strong and healthy may still be vulnerable to chemical exposures. Responses aren't solely predicted by a person's overall health condition or age.

If you feel dizzy, have difficulty breathing, or experience any other health symptoms while in a contaminated area, obtain medical advice immediately. If you are working on cleanup when these occur, it is especially important to protect yourself and your future health by going to an uncontaminated area and obtaining medical attention.

People carrying out demolition and other activities that require balance, coordination, and acute attention to detail may incur serious injuries if they attempt to work while impaired or ill. In addition, it is important to obtain guidance on personal protective equipment and safety strategies prior to carrying out such activities.

Exposure and Dose: Doing the Math.

Estimating exposure and dose isn't necessary in all situations, but some circumstances require it. The basic methods used to estimate exposure involve obtaining information on the following:

- Route of exposure (i.e., oral , inhalation, skin),
- The duration of exposure (hours, days, weeks, etc).
- Frequency of exposure (how many times per day, week, month, or year).
- Level of exposure - how much is in the air, water, food, soil, dust, etc.

There are extensive equations that can be used to estimate exposure and dose under numerous conditions. Detailed technical information to estimate exposure under various conditions is available in US EPA's Exposure Factors Handbook available online at http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

In a typical situation where there is airborne contamination, children's exposure is may be much higher than adults in relation to their body weight. This can result in a higher the amount that is absorbed and reaches critical organs and therefore greater toxicity. Premature infants and newborns are at especially high risk from skin exposure to contaminants in water because they have both an inadequate layer of fat under their skin that would usually reduce absorption, and they have a larger surface area of skin in relation to their body weight.

The dose, or amount reaching critical organs, that will result from any exposure is based on complex individual and situational factors. For example, when fuels come into contact with the skin, the dose depends entirely on the amount that is absorbed through the skin and enters the circulation. The dose that is delivered from fuel exposure on the skin is a function of:

- the duration and frequency of contact,
- the surface area of skin in contact with the fuel,
- the specific chemical composition and concentrations of chemicals in the fuel (some fuel ingredients facilitate the penetration of other ingredients through the skin),
- the condition of the skin before exposure occurs and any changes over time if exposure occurs more than once (damaged skin may allow for greater passage through skin layers or indicate reduced layers),
- whether the skin is damp,
- where on the body the skin is located (different locations have different skin thicknesses),
- various health conditions,
- many other individual and environmental factors.

As noted above, infants have a much more limited skin barrier and may absorb far more chemical ingredients than older children or adults.

To give a specific example of a common factor that impacts chemical absorption, many exposures during cleanup involve the use of soap, detergent, or other solvents. These non-toxic products remove the skin's barrier protection properties, making it easier for chemicals in fuels to absorb through the skin.

Many factors also impact the dose delivered through inhalation. As noted, it is not usually necessary to estimate dose. However, it is often helpful to understand what factors can increase the dose so that steps can be taken to minimize dose and harm.

The Additional Information section of this website lists multiple EPA documents in the Bibliography that address dermal absorption, exposure and related topics in detail.

Additional Information & Bibliography

Agencies are rapidly developing new resources. Consult their home pages regularly. We will update this as often as possible.

National Library of Medicine – extensive list of resources on health information related to Sandy
http://disasterinfo.nlm.nih.gov/dimrc/hurricanesandy.html#a3

OSHA – critical information on preventing health damage
Sandy http://www.osha.gov/sandy/index.html
Floods http://www.osha.gov/dts/weather/flood/response.html
http://www.osha.gov/OshDoc/data_Hurricane_Facts/floodcleanup.pdf
http://www.osha.gov/OshDoc/data_Hurricane_Facts/hand_hygiene_and_gloves.pdf
NIEHS (NIH) - List of relevant resources: http://tools.niehs.nih.gov/wetp/index.cfm?id=2472

Canadian occupational heath and safety on gasoline:
http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/gasoline/personal_gas.html

EPA – health hazard and public protection for the general public facing debris and damaged buildings: asbestos, mold, PCBs in electrical equipment and other critical issues
http://www.epa.gov/naturaldisasters/returnhomeadvisory.htm
Sandy http://www.epa.gov/sandy/frequentquestions.html
Natural Disasters in general: http://www.epa.gov/naturalevents/
Children: http://yosemite.epa.gov/ochp/ochpweb.nsf/content/flood.htm

New Jersey Work and Environment Council www.njwec.com

New York State Department of Health – on residential oil spills and flooding
http://www.health.ny.gov/environmental/indoors/air/oil_spill_flood.htm

NYCOSH – personal protective equipment and other information on protections
http://nycosh.org/index.php?page=hurricane-sandy

CDC – emergency response including Sandy http://www.cdc.gov/niosh/topics/emres/flood.html
Toxicological Profiles by the CDC-ATSDR (www.atsdr.cdc.gov/toxpro2.html

California's list of chemicals known to cause cancer and/or reproductive harm:
http://www.oehha.org/prop65/prop65_list/files/P65single040210.pdf

Buildings: ADAO on asbestos: http://www.asbestosdiseaseawareness.org/archives/15999
Architects on cleanup including asbestos: http://www.aia.org/about/initiatives/AIAS075276
Schools: http://library.constantcontact.com/download/get/file/1102175172120-230/Flooding+and+Schools.pdf

Pediatric health in floods: http://aoec.org/pehsu/documents/flood_hurricane_2011.pdf

FEMA: http://www.disasterassistance.gov
Children: http://blog.fema.gov/2012/11/keeping-children-safe-in-sandys-wake.html

Questions from physicians to Dr. Michael Harbut noraianc@karmanos.org 313-578-4282.
New Jersey Clinical Center for Occupational and Environmental Health 732-445-0123

Bibliography

The following sources were used to provide the information on this website.

APHA (American Public Health Association). 2002 Principles of the Ethical Practice of Public Health. V 2.2. Public Health Leadership Society of the APHA. Washington, D.C. http://www.apha.org/NR/rdonlyres/1CED3CEA-287E-4185-9CBD-BD405FC60856/0/ethicsbrochure.pdf

Burns KB and Melnick RL. 2012 . MTBE: Recent Carcinogenicity Studies. Intl J of Occup and Envir Health. January.

California provides a list of chemicals known to cause cancer and/or reproductive harm: http://www.oehha.org/prop65/prop65_list/files/P65single040210.pdf

Carpenter, D. et al.1998. Human health % chemical mixtures: An overview. Env Health Perspect. 106 Suppl 6. p1263-1270.

CDC Toxicological Profile access for all chemicals: http://www.atsdr.cdc.gov/toxprofiles/index.asp

CDC. 1995. Toxicological Profile for Gasoline, ATSDR. Atlanta Georgia.
CDC. 1999. Toxicological Profile for Petroleum Hydrocarbon Fuels, ATSDR, Atlanta GA.
CDC. 2000. Toxicological Profile for Toluene. ATSDR, Atlanta Georgia
CDC. 2007. Toxicological Profile for Benzene. ATSDR, Atlanta Georgia
CDC. 2007. Toxicological Profile for Xylenes. ATSDR, Atlanta Georgia

Chen et al. 2008. Assessment of genotoxicity of mtbe, benzene, toluene, ethyl benzene, xylene to human lymphocytes using comet assay. *J Haz Mater*. May 1;153(1-2):351-6.

Dietrich, et al. 2005. Principles and Practices of neurodevelopmental assessment in children: lessons learned from the Centers for Children's Environmental health and Disease Prevention Research. *Environ Health Persp*. Oct:113(10) 1437-46.

Grandjean et al. 2007. Faroes Statement: Human Health Effects of Developmental Exposure to Chemicals in Our Environment. (International Conference on Fetal Programming and Developmental Toxicity). Basic Clin Pharm & Tox. 102, 73-75 http://www3.interscience.wiley.com/cgi-bin/fulltext/119425369/PDFSTART

Forssen U. et al. 2007. Predictors of use and consumption of public drinking water among pregnant women. J Expo Sci Environ Epidemiol. Mar;17(2), pp 159-169.

International Agency for Research on Cancer (IARC via Baan et al). 2009. A review of human carcinogens—Part F: Chemical agents and related occupations. The Lancet Oncology, Volume 10, Issue 12, Pages 1143 - 1144, December 2009 . (Table of chemicals & decisions : http://www.thelancet.com/journals/lancet/article/PIIS1470204509703584/table?tableid=tbl1&tableidtype=table_id&sectionType=lightBlue

LaDou, J. Editor. 2007. Occupational and Environmental Medicine, 4th Edition. McGraw Hill, NYC, NY. Multiple chapters by various authors.

Michaels, D. 2006. Manufactured Uncertainty, Protecting Public Health in the Age of Contested Science and Product Defense, *Ann NY Acad Sci.* Vol 1076; 149-162.

National Academy of Sciences. 1996. Understanding Risk: Informing Decisions in a Democratic Society. National Academy Press. Washington, D.C. http://books.nap.edu/catalog.php?record_id=5138

National Research Council (NRC). 1993. Pesticides in the Diets of Infants and Children. National Academy of Sciences Press. Washington D.C.

National Toxicology Program. 2011. 12th Report on Carcinogens. NIEHS. Research Triangle Park, NC http://ntp.niehs.nih.gov/?objectid=03C9AF75-E1BF-FF40-DBA9EC0928DF8B15

Sekkal, S et al. 2012. Occupational Exposure to Petroleum Products and Respiratory Health: A Cross-Sectional Study From Algeria Jnl Occ Env Med 54:11 1382-88 Abstract: http://journals.lww.com/joem/Abstract/2012/11000/Occupational_Exposure_to_Petroleum_Products_and.11.aspx

U.S. EPA. (1992a) Dermal exposure assessment: Principles and applications, Interim Report. Exposure Assessment Group, Washington, D.C.

U.S. EPA. 2000. Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures. Washington, D.C.

US EPA, 2002 (Benzene) : http://www.epa.gov/ttn/atw/hlthef/benzene.html

U.S. EPA. 2004. Risk Assessment Guidance for Superfund, Vol. Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment. Final. Washington, D.C.

U.S. EPA. 2005. Guidelines for Carcinogen Risk Assessment and Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Washington, D. C.

U.S. EPA. 2006. Using Science to Improve Risk Assessment. National Center for Environmental Assessment. Washington, D.C.

U.S. EPA. 2007. Guidelines for Exposure Assessment. National Center for Environmental Assessment, Washington, D.C.

U.S. EPA. 2008. Child-specific Exposure Factors Handbook,. National Center for Environmental Assessment. Washington, D.C.

US EPA. 2011. Exposure Factors Handbook
http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252

WHO (World Health Organization). 2004. "The precautionary principle: Public health, protection of children and sustainability. Publications Office. Copenhagen, Denmark. http://www.euro.who.int/document/e83079.pdf

WHO. 2006. Children's Health and the Environment in North America. CEC. Montreal, Quebec, Canada. www.cec.org/files/pdf/pollutants/ceh-indicators-fin_en.pdf

WHO. 2007. Preventing Disease Through Healthy Environments: towards an estimate of the environmental burden of disease. Geneva, Switzerland.
www.who.int/quantifying_ehimpacts/publications/preventingdisease.pdf

Authors and Acknowledgements*

Kathleen Burns, PhD, is the Director of Sciencecorps in Lexington, MA. Dr. Burns has worked for state and federal agencies, published books and papers in toxicology, epidemiology, and risk assessment, manages investigations of air, water, soil, and food contamination and works on chemical & public health policy development. Contact: infofuels <at the domain> sciencecorps.org

Michael Harbut, MD is a Clinical Professor of Internal Medicine and Director of the Environmental Cancer Program at Wayne State University's Karmanos Cancer Institute in Michigan. Board Certified in OEM, his research has been published or presented in venues ranging from the New England Journal of Medicine to the White House. Contact via Cynthia Noraian at noraianc <at the domain> karmanos.org or during business hours at: 313-578-4282.

John Braiman. Photographer. Mr. Braiman is a photographer in Brooklyn New York who does both commercial and fine art. He has done considerable work in urban landscapes and portraiture, with a special interest in social commentary. Some of his work can be seen at: http://www.johnbraimanphoto.com/commercial/index.html

Acknowledgements

Peter Burns, BS, CISSP of Lexington, MA carried out the technical preparation of the website and assisted with text editing of the content. He is an information technology specialist who has over 30 years of experience in internet security and Linux systems administration.

Alice Freund, MS of Montclair, New Jersey is an industrial hygienist with over 30 years of experience with worker health and safety programs in New Jersey and New York. She has developed many training materials on chemicals, physical hazards, ergonomics and other topics.

Michael Wright, MS is Director of Occupational Health and Safety for the International Steelworkers based in Pittsburg, PA. He has more than 20 years of experience working on health and safety issues involving chemical exposures.

Kenneth Rudo, PhD of Raleigh-Durham, North Carolina has been the state toxicologist in North Carolina for over 20 years and has worked extensively on the identification, cleanup, and public health aspects of chemical spills in his state and elsewhere.

Thanks also to professionals who contributed to this webpage and wanted to remain annonymous.

***The participation of these parties does not indicate their agreement with all content. Affiliations are listed for identification purposes only & do not indicate institutional agreement with content.**

Sciencecorps, LLC Lexington, MA, USA