Section A - 1

HAZARDOUS MATERIALS AND HUMAN HEALTH

A. What is a Hazardous Material?

The terminology surrounding hazardous materials can be best described as confusing. Many terms appear similar but have very different regulatory meanings. When you are unsure about the meaning of a term, remember that legal definitions are found in individual regulations. When dealing with hazardous materials, several key definitions must be addressed and understood.

1. Solid Waste

Solid waste is a catch-all term used by the U.S. Environmental Protection Agency (EPA) to define all solid, liquid and gaseous waste. Hazardous, chemical, infectious and medical wastes are subcategories of solid waste that can threaten human health or the environment because they may be potentially harmful (See Figure 1).

2. Hazardous Material

This term is also used in a <u>broad</u> sense. A hazardous material is any substance or mixture of substances having properties capable of producing adverse effects on the health and safety or the environment of a human being. Hazardous materials include hazardous substances, hazardous waste, hazardous chemicals and medical waste.

3. Hazardous Substance

This term includes chemicals, mixtures of chemicals, or materials as defined in CERCLA (commonly referred to as Superfund). Accordingly, Superfund regulations (40 CFR 302) encompass hazardous substances which are identified in the List of Lists for Regulated Hazardous Substances.

4. Hazardous Waste

This term is defined in the Resource Conservation and Recovery Act (RCRA) as a solid waste or combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristics may:

a. cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness, or

b. pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

c. The regulations that implement RCRA, in part, 40 CFR 261 states that a hazardous waste either has a "characteristic" of a hazardous waste or is "listed" as a hazardous waste.

d. "Listed" hazardous wastes are summarized below:

1) Discarded Commercial Chemical Products known to be toxic (U-list), or acutely toxic (P-list).

2) Container residues and rinsates from acutely toxic (P-listed) chemicals.

3) Wastes generated by specific manufacturing processes, as identified in the K-list (none of which are generated on the UNO campus).

4) Solvent waste from non-specific sources as identified in the F-list (many of which are generated on the UNO campus).

e. "Characteristic" hazardous waste exhibits any of the following characteristics:

1) Ignitability

Substances defined by this characteristic include the following:

i) Liquids, other than aqueous solutions containing less than 24% ethyl alcohol by volume, that have a flash point below 60° C (140°F).

ii) Nonliquids that are capable of causing fire by friction, absorption of moisture, or spontaneous chemical changes and, when ignited, burn vigorously and persistently to create a hazard.

iii) Flammable compressed gases.

iv) Oxidizers such as chlorates, permanganates, inorganic peroxides, or nitrates that yield oxygen readily to stimulate the combustion of organic matter.

2) Corrosivity

Substances considered corrosive include the following:

i) Aqueous solutions that have a pH equal to or less than 2 or equal to or greater than 12.5.

ii) Liquids capable of corroding SAE 1020 steel at a rate greater than 6.35 mm/year at 55EC.

3) Reactivity

Substances that react with water violently or to produce toxic gases or explosive mixtures, substances that are unstable, explosives, and substances that contain cyanide or sulfide that generate toxic gases when exposed to a pH in the range between 2 and 12.5.

4) Toxicity

i) Substances which demonstrate toxicity based on an EPA-approved test procedure. The process commonly used is called "Toxicity Characteristic Leaching Procedure" (TCLP).

ii) TCLP: This characteristic identifies wastes from which certain toxic materials could be leached into groundwater supplies and is defined by a prescribed test procedure for water extraction of the waste.

Eight elements or ions	Thirty-one organic substances	
Arsenic (As)	benzene	hexachloroethane
Barium (Ba)	carbon tetrachloride	lindane
Cadmium (Cd)	chlordane	methoxychlor
Chromium (Cr)	chlorobenzene	methyl ethyl ketone
Lead (Pb)	chloroform	nitrobenzene
Mercury (Hg)	o-cresol	pentachlorophenol
Selenium (Se)	m-cresol	pyridine
Silver (Ag), and	p-cresol	tetrachloroethylene
	1,4-dichlorobenzene	toxaphene
	1,2-dichloroethylene	trichloroethylene
	1,1-dichloroethylene	2,4,5-trichlorophenol
	2,4-dinitrotoluene	2,4,6-trichlorophenol
	endrin	vinyl chloride
	heptachlor	2,4-D
	hexachlorobenzene	2,4,5-TP silvex
	hexachloro-1,3-butadiene	

The extract is analyzed for concentrations of:

5. Hazardous Chemical

This term describes a chemical or material used in the workplace that is regulated under the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard or the "employee right-to-know" regulations in 29 CFR 1910.1200.

6. Medical Waste

Medical waste is sometimes referred to as red-bag waste or infectious waste. In Nebraska, the disposal of infectious waste is regulated by the NDEQ as a special waste pursuant to Title 132. It is required to be incinerated, autoclaved, or treated by other means approved by NDEQ to render it non-infectious prior to landfilling. Once treated, it is no longer a special waste except for incinerator ash. Infectious medical waste is also regulated by the City of Omaha, Chapter 33, Omaha Ordinance.

Pursuant to Title 132, "infectious waste" shall mean a solid waste capable of causing an infectious disease. For a waste to be deemed infectious, consideration will be given to those

elements required in order for infection to occur. These elements include the presence of a pathogen or causative organism, of significant virulence, in an adequate dose, which is able to gain a portal of entry in a susceptible host. Infectious waste shall include, but not be limited to, substances from the following classifications:

a. Blood, Blood Products and Body Fluids

This classification includes fluid blood, blood products and body fluids, and any items contaminated with any of these fluids, if a pourable quantity (ability of a liquid or semi-solid form to drip or flow) is present. The term blood and blood products includes serum, plasma, and other blood components. The term body fluid includes semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, peritoneal fluid, pericardial fluid, amniotic fluid and any other body fluid visibly contaminated with blood.

b. Infectious Sharps Waste

This classification includes all discarded items from diagnosis, treatment, or immunization which can potentially transmit disease by breaking the human skin, and includes hypodermic needles, scalpels, razor blades, breakable glass containers, blood vials, culture dishes, used slides, glass products and broken glass or other sharp items that have come into contact with or have been contaminated by material considered infectious.

c. Laboratory Waste

This classification includes all cultures and stocks of infectious agents, including specimen cultures from medical and pathological laboratories, cultures and stocks from research and industrial laboratories, wastes from the production of biologicals, discarded live and attenuated vaccines, and culture dishes and devices used to transfer, inoculate, and mix cultures.

d. Animal Waste(Contaminated)

This classification includes blood and body fluids, carcasses, body parts, excrement and bedding from animals contaminated with agents that may cause human disease.

e. <u>Animal Waste(Non-Contaminated)</u>

This classification includes blood and body fluids, carcasses, body parts, excrement and bedding from animals free of contamination. This includes specimens from anatomy and biology labs. Disposal by this method ensures no improper handling or disposal.

f. Waste Identified by Infectious Waste Generators

This classification includes those wastes determined by the infectious waste generator or the UNO/UNMC joint biosafety committee to be treated as infectious waste because of the risk of disease posed by such waste.

g. Transport of Infectious Waste

Prior to transport, all infectious waste shall be placed in rigid or semi-rigid, puncture resistant, leak-proof containers clearly marked with the universal Bio-Hazard symbol prominently displayed and labeled "Infectious Waste" or "Bio-Hazard Waste" and sealed. All containers shall be closed in such a manner as to contain all waste and the outside of the container shall be kept free of contamination.

B. Why are Hazardous Materials a Concern?

Many commercial products make use of materials that do not exist in nature. Some will require careful handling during manufacture, transport, storage, use, and disposal in order to avoid causing harm to people, other living things, and the environment.

Many of these chemicals are not "biodegradable" (that is, able to be broken down into their components by microorganisms); for such chemicals in particular, the potential for adverse health effects can continue for decades.

By becoming informed about hazardous materials laws, issues, and protective actions, we can contribute to reducing our hazardous materials threat.

C. How can Hazardous Materials be Released?

A "release" may occur by spilling, leaking, emitting toxic vapors, or any other process that enables the material to escape its container, enter the environment, and create a potential hazard. Hazards are classified in many different ways. The following introduces several common terms:

1. **Explosive** substances release pressure, gas and heat suddenly when they are subjected to shock, heat or high pressure.

2. **Flammable** and **combustible** substances are easy to ignite. Paint thinners, charcoal lighter fluid, and silver polish are all highly flammable. Related hazards are posed by oxidizers, which will lend oxygen readily to support a fire, and reactive materials, which are unstable and may react violently if mishandled.

3. **Poisons** (or toxic materials) can cause injury or death when they enter the bodies of living things. Such substances can be classified by chemical nature (for example, heavy metals and cyanides) or by toxic action (such as irritants, which inflame living tissue, and corrosives, which destroy or irreversibly change it).

These categories are not mutually exclusive. For example, acids and bases are listed as corrosive materials, but can also act as poisons.

D. How Do Hazardous Materials Harm the Body?

Toxic substances can enter our bodies in any of four ways, called routes of entry. These are:

*Absorption	*Ingestion
*Injection	*Inhalation

1. Absorption (through the skin or eye)

If an individual were to walk barefoot through contaminated soil, the contaminant would contact the skin of the foot. This could cause mild skin irritation, or more serious problems like burns, sores, or ulcers on the outer layers of the skin. Contact with a substance may also occur by spilling it on the skin or brushing against a contaminated object.

Depending on the substance and the condition of the skin, the contaminant might also be absorbed through the skin. While some chemicals are not absorbed easily unless the skin is cut, others are absorbed quite readily regardless of the skin's condition. When an individual uses a material that bears instructions recommending the use of gloves, this is to prevent skin contact or absorption through the skin (also called dermal exposure).

When an individual works with chemicals, it is particularly important never to put your hand to your eye. Eyes are particularly sensitive to toxic substances: since capillaries are near the surface, the substance can enter the bloodstream more readily. Eye contact with toxic substances can cause irritation, pain, or even blindness.

2. Injection

The most familiar example of injection is that of shots given to administer medicine, in which the skin is punctured with needles so that a substance can enter the body. Injection can also occur accidentally. For example, if the skin were cut by a contaminated can or a piece of glass that had been in contact with a contaminant, the contaminated substance could be injected into the body. This is a very powerful means of exposure because the contaminant enters the bloodstream immediately.

3. Ingestion

If an individual ingests a substance that contains a harmful material, that substance enters the body by means of the digestive system. An example of inadvertent ingestion is a battery factory employee who eats lunch in the work area and ingests inorganic lead that has contaminated a sandwich. A more common instance is the child who puts a toxic substance in his or her mouth out of curiosity. Residue from chemicals that have been added to food to kill germs or parasites may also be ingested.

4. Inhalation

It is also possible to be contaminated by toxic substances by breathing them into the lungs. The amount of air inhaled in a workday can be extremely large, so if an individual works or lives in a contaminated area, he or she can be exposed to significant quantities of a substance in this way.

Some chemicals have excellent warning properties that let us know when they are in the atmosphere. There is the well-known "rotten egg" smell of hydrogen sulfide, for example. But at high concentrations of this gas, our sense of smell is quickly lost. Many toxic substances, such as carbon monoxide, are both colorless and odorless, providing us with no sensory clues that the exposure is anything unusual.

E. Pathways of Exposure

In considering the routes of entry identified above, there are a number of ways in which contaminants escaping into the environment from their source may reach a living plant or animal, or receptor. Each specific route a chemical might travel from a source to a receptor is called an exposure pathway.

The pathway may be either direct or indirect. Inhaling a toxic vapor is an example of direct means of exposure. Drinking contaminated water as a result of toxic particles leaching into the soil is an example of an indirect pathway.

F. Toxic Materials in the Body

A poison, or toxic substance, may be defined as a chemical that, in relatively small amounts, produces injury when it comes in contact with susceptible tissue. Clearly, the phrase "relatively small amounts" is less than precise, but this uncertainty is necessary because of the wide variance in the amount of each chemical needed to have an effect. A substance is generally not thought of as toxic if it is unreasonable to expect that a person would be exposed to the amount necessary to cause injury. A "susceptible" tissue is defined as that part of the body which is injured after exposure to that particular substance.

1. Toxic Effects

We can be exposed to poisons in either of two ways. The first is called acute exposure, which means a large exposure over a short period of time (typically less than 24 hours). The second is called a chronic exposure which means repeated small exposures over a long period of time.

Exposure to a toxic substance can produce either immediate or long-term effects. A reaction to a poison can occur at the time of exposure, and might include vomiting, eye irritation, or other symptoms that often may be readily linked to a chemical exposure. These are immediate effects.

Long-term effects may occur years after a single serious exposure, or as the result of chronic exposure. These effects are often more difficult to trace to their cause, and can include organ damage respiratory diseases, and other illnesses.

Certain toxic substances produce their long-term effects by altering the genetic code, or DNA, which tells the body's cells to perform certain activities. Three categories of effects can result from such substances:

a. A carcinogenic effect is an increase in an individual's risk of contracting cancer.

b. A mutagenic effect is a permanent change in the genetic material (DNA), which may be passed along to later generations.

c. A teratogenic effect is an increased risk that a developing embryo will have physical defects.

Determining what level of exposure causes these effects requires laboratory research under controlled conditions. Even then, results must be extrapolated from laboratory animals to humans. That is, scientists must make assumptions and apply formulas to decide what their experiments tell them about human exposures.

Another way to classify poisons is by their physiological effects. This classification includes the following major groups:

a. **Irritants** are chemicals that inflame living tissue at the site of contact, causing pain and swelling.

b. **Asphyxiants** are chemicals that prevent the cells of the individual from receiving life-giving oxygen. Carbon monoxide is a well-known asphyxiant, which chemically "ties up" the hemoglobin in the blood so that the body's metabolism slows and stops.

c. **Central Nervous System (CNS)** depressants affect the nervous system. This broad category includes vapors from most anesthetic gases, depressants, and organic solvents (a general category that includes many paints, glues, adhesives, and alcohol). Some CNS depressants produce a feeling of dizziness or giddiness. More severe effects (including death) can also result.

d. **Systemic Toxins** dramatically affect specific organ systems. For example, mercury vapor can cause a serious nervous system disorder which could lead to insanity.

Many chemicals can have multiple effects. For example, xylene is both an irritant and a CNS depressant. Symptoms of toxic exposure include a broad range of reactions: chronic coughs, difficulty in breathing, skin ulcers, diarrhea, irregular heartbeat, headaches, dizziness, chest pain, sore eye and skin, difficulty in sleeping, lack of appetite, weight loss, nausea, tremors, and many others. However, the same symptoms can result from many other causes as well. Tracing a particular reaction to a specific source can be a challenge to even the most experienced environmental toxicologists, allergists, and industrial hygiene specialists. This is further complicated by the fact that many effects are delayed, and apparent only later in life.

2. Internal Defenses

When the body is exposed to a toxic substance, its internal defenses try to remove the unwanted substances. The primary internal defense is excretion of the contaminant with other wastes in the feces or urine. Prior to excretion, wastes are filtered, primarily by the liver and kidneys. As a result, these two organs are both subject to damage from toxic substances, storing in their tissues what they are unable to break down. Portions of the lungs contain cilia, which try to remove particles that then may be coughed out. Particles that are too large or cannot be removed for

other reasons sometimes remain as deposits in the lower part of the lungs, where they can cause toxic effects such as fibrosis or cancer.

Other body defenses against toxic substances are breathing and sweating. When an intoxicated person has the smell of alcohol on his or her breath, the smell indicates that the body is exhaling material it has no use for. Tears also remove contaminants that enter the eyes. However, these defenses contribute only a small amount to the body's detoxification (that is, its attempt to rid itself of toxic substances).

The body's ability to defend itself against toxic substances varies with the individual. Small children are liable to be more affected by the same amount of a substance than are larger or older persons. Elderly individuals also may have less ability to remove toxins from the body. Gender can be a factor in toxic responses; for example, some cancers are sex-linked (such as prostate and ovarian cancers). Personal hygiene and the overall health of an individual can also adversely affect the body's ability to process certain toxic substances.

Certain people also have allergies to substances that can cause them to react violently, even fatally, to a situation that would pose no apparent risk to another individual. Chemicals that cause strong allergic reactions in some people are called sensitizers. For example, epoxy resins and polyester resins cause many people to have a sensitivity reaction and become ill.

Exposure to a toxic substance becomes a problem when the material is of a type that inner defenses cannot break down and remove, or when there is more of it than the body can handle. In these instances, antidotes are available for a limited number of substances. However, only about 20 antidotes are in existence for the thousands of poisons in the world.

Clearly, the safest barrier to toxic exposure is the prevention of exposure. This is why it is so important to be aware of the threat posed by hazardous materials, and to learn to minimize or eliminate unnecessary exposure.

G. Studies of Toxic Effects

Scientists determine what levels of exposure in human beings will produce observable symptoms by two types of studies. Epidemiological studies use data on how toxic substances affect human populations. This type of study might compare the number of workers exposed to a certain substance who develop lung cancer to those who develop it in the rest of the population. Other clinical studies test the effects of concentrated doses of substances on animals or animal tissue.

A basic principle of research on toxic substances is that the seriousness of the effect increases as the dose increases. Theoretically, there is a threshold for exposure to each substance. Beneath the threshold, the dose is so small that no harmful effect will occur. As the dose increases, here is a point at which there is an effect, but the organism can compensate for it by internal healing, and no permanent injury will occur.

Beyond that, there is a dose at which the animal cannot repair itself from the damage and disease results. Finally, at the upper limit of the curve, death occurs.

Death would occur if sufficient quantities of any substance were taken into the body. Through experiments, scientists try to establish the particular dosage of chemical (in mass per kilogram of body weight) that will result in the death of half the test animals: that is the Lethal Dose for 50% or LD_{50} . They also try to establish the point at the other end of the curve at which there is no observable effect from the substance on the animal. This is called the NOAEL: No Observable Adverse Effect Level.

Once the LD_{50} for a substance has been established by repeated experiments with animals, it must be extrapolated to determine what the LD_{50} would be for humans. This means adjusting the results to apply to human body weight and similar characteristics. But a toxic substance often has different effects on different species, so tests on animals cannot predict the exact effect that the substance will have on a human population. As a result, scientists are usually quite conservative in their estimates, which means that they assume that the smallest dose that causes an effect in animals will also cause an effect in humans. In addition, scientists study the effect of a substance on human populations wherever statistics are available.

Another uncertainty associated with the LD_{50} concept is that most LD_{50} data is gained from acute exposure (single dose) testing rather than by chronic exposure. Extrapolation from these studies is complicated by the fact that chemicals are sometimes distributed differently in the body when the exposure is chronic; for example, a different target organ may be attacked, or the material may be excreted more easily.

Given these uncertainties, it is understandable why there is often considerable debate about what constitutes a "safe" level of exposure. For most substances, agency experts extrapolate conservatively from the NOAEL to set exposure limits for humans. The Occupational Safety and Health Administration (OSHA) uses "Permissible Exposure Limits," or PELs, while the American Conference of Government Industrial Hygienists (ACGIH) uses "Threshold Limit Values," or TLVs, to define the workroom air concentration that is considered a safe upper limit of exposure. For carcinogens and mutagens, however, there is considered to be no such "safe" exposure limit for regulatory purposes. Every exposure carries some risk.