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Stachybotrys: Is Nevada at risk?

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Is Nevada at Risk?

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ABSTRACT

Stachybotrys chartarum (atra) is a toxigenic fungus that is known to adversely impact the health of animals. Until recently, there have only been a few documented clinical reports linking Stachybotrys chartarum to human health effects. Scientists are increasingly convinced that Stachybotrys and its metabolites are responsible for several adverse health effects experienced by people all over the world, although conclusive proof has yet to be established. All the physical requirements needed for indoor Stachybotrys sporulation and growth is provided through water leaks (plumbing, roof or ceiling), flood events, nutrient sources (cellulose and nitrogen), pH, and temperature(23° - 28°C). Stachybotrys has been found in several climates around the world that are similar to those found in Nevada. Conditions that support Stachybotrys growth and confirmed contamination site locations were also similar to those found in Nevada. Also, Nevada residents who reside/work in water damaged buildings that have confirmed Stachybotrys contamination have reported similar symptoms to those mentioned in the reviewed literature. Unfortunately, scientists have not identified human toxicity levels or the dose/response relationship for humans exposed to Stachybotrys chartarum due to the lack of test subjects who were exposed and their willingness to undergo testing. Scientists are also trying to determine whether not reported Stachybotrys-related illnesses are the result of exposure to Stachybotrys alone or if there are synergistic effects with other bioaerosols and molds. What is known is that Stachybotrys spores often contain toxigenic properties, such as, macrocyclic trichothecenes which can be absorbed into the body through ingestion, skin contact, or inhalation. Nevadans who work or reside in Stachybotrys-contaminated buildings may be at risk. Health effects are numerous and may be life threatening depending on the person's age, exposure (duration and route), and toxicity level. Medical professionals and consultants should consider microbial contaminants in their assessment of their patients because there is a potential risk that Nevadans may have been exposed to Stachybotrys and its metabolites. Industrial hygienists should use a multi-method approach when collecting and analyzing microbial samples because it has a higher fungal detection rate than single method sampling.

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INTRODUCTION

The mold, Stachybotrys chartarum, and its [1]*metabolites*, have been identified in numerous locations throughout the world. Researches have described its *toxigenic* properties and its affect on humans and animals. Stachybotrys has been identified as a hazardous substance as a result of a risk assessment, and it has been positively identified in Nevada. The purpose of this thesis is not only to provide a detailed description of Stachybotrys chartarum (atra), including how it is transported, and what its growth requirements are, but also to explore whether or not Stachybotrys can survive in Nevada (indoors or outdoors) by comparing Nevada's climate with other geographical and physical locations where Stachybotrys contamination has been confirmed. Animals have contracted several Stachybotrys-related diseases from ingesting moldy feed for thousands of years. Recently, Stachybotrys has been linked to human illnesses. In late November, 1994, the Centers for Disease Control and Prevention (CDC) investigated an outbreak of pulmonary hemorrhage and hemosiderosis in Cleveland, Ohio. The CDC believes they found strong evidence linking Stachybotrys chartarum exposure to illness and deaths in infants. If Stachybotrys can thrive in Nevada, local health professionals need to know what, if any, health effects may occur with exposure of toxigenic fungi, as well as determining what the target organs are.

This study will describe the fungus Stachybotrys chartarum, its growth requirements, its dissemination methods, and its physical and geological locations. The thesis will also cover some medical issues on a limited basis, such as, health affects, related diseases, symptoms and target organs. A brief section on exposure routes will explain how people become exposed to Stachybotrys. The discussion of toxicity explains why Stachybotrys may be harmful to humans. Because Stachybotrys is new to most health and environmental professionals, a segment on measurement limitations is included to explain why Stachybotrys is sometimes difficult to identify and how other fungi and bacteria add to the negative health effects that exposure to Stachybotrys *toxin* and its metabolites may produce. The measurement limitations section also explains why a multi-method sampling approach is better than a single-method sampling approach.

In determining whether Stachybotrys chartarum can survive in Nevada, one must define Stachybotrys, determine its dissemination methods, and establish its survival needs. An extensive literature review reveals that Stachybotrys has a high tolerance to temperature extremes and can be disseminated by floods, air currents, and vector movement. Stachybotrys chartarum sporulates and grows when it has a continuous food and water supply. Research revealed that Stachybotrys proliferates readily in Nevada. Interviews with risk management specialists and microbiologists revealed that several Stachybotrys contamination cases have been confirmed in Nevada. Specific information on these cases and related health information was not available due to confidentiality issues. Most of these cases are currently under litigation. Only two local accounts of Stachybotrys contamination and related health effects have been reported in the local newspapers. Several reported symptoms matched those of Stachybotrys chartarum exposure that were uncovered during the literature review process. Additional research connecting local health complaints to the Stachybotrys exposure episode was not possible due to the inability to follow-up on the reported cases due to pending litigation. An excellent topic for further study would be to analyze the health affects of Stachybotrys

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[1] Italicized words are defined in the glossary.

exposure on people that reside/work in confirmed Stachybotrys-contaminated buildings in Nevada.

LITERATURE REVIEW

Deitchman, Martnez, & Upham (1994); Croft, Jarvis, Yatawara (1986); the American Conference of Governmental Industrial Hygienists (ACGIH)(1989); Malloch, (1997); Johanning, (1997a) and Dearborn, Infeld, Smith, Allan, & the Cuyahoga County Board of Health (1998, February), provided background information about the Stachybotrys chartarum genus, physical description, characteristics, common growth areas and conditions. It is important to know what Stachybotrys chartarum looks like and which conditions are favorable for its sporulation and growth. Once the conditions are known, steps can be taken to eliminate them, thus preventing human exposure to the toxigenic spores.

Johanning et al., (1993b); Pasanen, Nikulin, M., Tuomainen, Berg, Parikka, Hintikka, (1993); Sorenson, Kullman, and Hintz, (1996); Andersson, Nikulin, Koljalg, Andersson, Rainey, Reijula, Hintikka, & Salkinoja-Salonen,(1997); Esswein, Wilcox, & Lonon, (1994); Johanning, (1997b); Croft, et al., (1986) each provided temperature and relative humidity for Stachybotrys sporulation and growth. There were minor variations in the temperature and relative humidity ranges, but the information in each case study was relatively consistent. Spore dissemination methods were provided by Johanning (1997b). Information about dissemination methods, temperature and relative humidity is important because Stachybotrys spores travel long distances, under a wide variety of weather conditions.

Stachybotrys has been found in a variety of locations throughout the world. Johanning et al. (1993b), Esswein et al (1994), Johanning, Biagini, Hull, Morey, Jarvis, & Landsbergis (1986), Deitchman, et al. (1994 Montaña, Etzel, Allan, Horgan, & Dearborn (1997), and Stetzenbach (personal communication, 1998, July 20; 1998, October 10; and 1998, October 16) found Stachybotrys in several water damaged buildings including: hospitals, houses, schools, offices, and libraries. This information revealed the type of locations in which Stachybotrys can thrive. The data was also helpful when it was used to compare worldwide Stachybotrys contamination locations to contaminated sites in Nevada.

Johanning, et al. (1993b), Croft, et al. (1986), Montaña, et al. (1997)and Marwick (1997) provided information about how floodwater can contribute to Stachybotrys growth. Marwick (1997) wrote an article, "Foods carry potential for toxic mold disease", which included a cautionary note that Stachybotrys was found in the floodwater damaged homes in Cleveland, Ohio, but that the correlation between pulmonary hemorrhage and the presence of fungi in the homes of the affected infants requires further clarification and study.

Johanning, 1993b), Johanning, (1997b) reported that Stachybotrys toxins gain entry into the body through three exposure routes: ingestion, inhalation and skin contact. Pasanen, Nikulin, Tuomainen, Berg, Parikka, and Hintikka, (1993) said that ingestion is the main route of *mycotoxin* exposure in animals. Humans can also become exposed to Stachybotrys in this manner; however, inhalation is probably the most common exposure route for humans. Croft, et al. (1986), Pasanen, et al. (1993), and Deitchman, et al. (1994) agreed that Stachybotryotoxicosis is the result of animals eating contaminated feed and that only very few, less detailed clinical reports of human cases of human stachybotryotoxicosis are available (Johanning, et al., 1993a). Additional testing needs to be done to confirm stachybotryotoxicosis in humans. Deitchman, et al. (1994) and Johanning, (1997b) mentioned the effects Stachybotrys can have on skin after direct contact occurs. Each believes that specific symptoms will occur if someone physically touches the fungus. James Craner (personal communication, 1998, November 18) MD, MPH, a Reno Occupational and Environmental Medicine Physician disagrees. He indicated that there is no conclusive evidence that links skin irritations to direct dermal contact with Stachybotrys. Skin rashes and other symptoms appear to be a systemic skin response and that the mechanism for this response is, as with other effects, unclear (1998). According to Deitchman et al. (1994), it is unknown if systemic effects can occur due to skin absorption. Inhalation of mold spores is another common Stachybotrys chartarum exposure route (Yang, 1994; Johanning, et al., 1996). Croft, et al., (1986) and Sorenson, et al. (1996) said they found Stachybotrys at various locations in collected air samples. Croft, et al. (1986) and Pasanen, et al. (1993) acknowledged that respiratory exposure can occur when people come into close contact with contaminated materials, such as rice or grain. Occupational exposure due to inhalation can be a serious exposure because inhalation to mycotoxins is a much more potent route of exposure than ingestion, requiring a smaller dose to produce toxic effects. Understanding how Stachybotrys exposure occurs can aid regulators when writing exposure guidelines or regulations for at risk people in occupational settings. This knowledge can also assist medical personnel identify better treatment methods for Stachybotrys-related illnesses.

Johanning, et al. (1993b) and Johanning, et al. (1996) reported that Stachybotrys produces a macrocyclic trichothecene, satratoxin H and spirocyclic lactones. The study documents that the mycotoxin, satratoxin H, had been classified a hazardous substance following a risk assessment. Johanning, Morey, & Jarvis 1993a, found the potent cytotoxin, satratoxin H, in case samples they analyzed. Sorenson, Frazer, Jarvis, Simpson, Robinson, (1987) analyzed Stachybotrys contaminated materials and found trichothecene mycotoxins in them. Croft, et al. (1986) also found trichothecene mycotoxins in aerosolized sores of Stachybotrys atra. In a different analysis, Croft analyzed a sample of Stachybotrys from his basement and found that it was not toxic at all. Pasanen et al. (1996)also found that some filter samples she studied were not toxic, although others filter samples did produce macrocyclic trichothecenes. This information is important because it confirms that Stachybotrys does contain toxic properties; how ever, Stachybotry's presence does not automatically mean it is toxic, or that it is present in large enough quantities to become a health threat. The route of exposure is significant when determining risk. Information on dose response relationships has not yet been addressed. Data is not available that can conclusively link Stachybotrys to adverse human health because most of the tests were not performed on people. According to Johanning, et al (1993b), remediation techniques used in removing materials contaminated with

Stachybotrys are similar to asbestos abatement. Every precaution must be made to reduce the spread of the fungal spores and eliminate human exposure.

Andersson, et al. (1997) discussed the shortcomings of current of methods available for sampling, isolating, and identifying microorganisms. Current sampling techniques do not adequately represent the true microbial population. The germination and growth of Stachybotrys chartarum is slow compared to other genera and its growth is often inhibited by Penicillium. Only a fraction of the Stachybotrys conidia are viable in laboratory cultures. The authors of this study recommend that a multimethod approach be used when collecting and analyzing microbial samples.

Several case studies described health complaints of employees that were working in severely water damaged buildings which had positively identified Stachybotrys fungus contamination in the buildings. Croft, et al. (1986) described the health complaints of a family that had a Stachybotrys contamination in their home and Johanning, et al., 1996 evaluated the health status of office workers who were exposed to Stachybotrys chartarum. Deitchman, et al. (1994) Johanning (1997c) described several human diseases that were attributed to Stachybotrys, although sufficient numbers human toxicology tests are not available to conclusively substantiate this conclusion.

Dearborn, et al. (1998); MMWR (1998), Montañ et a1. (1997) reported that from 1993 to 1998, 34 cases of pulmonary hemorrhage and hemosiderosis in infants had been identified in Cleveland, Ohio. The basic line of evidence indicated that the toxins found in Stachybotrys atra was the cause of the babies' illnesses and deaths; however, it was noted that the epidemiological data did not conclusively link Stachybotrys atra to these pulmonary hemorrhage and hemosiderosis incidences. The Morbidity and Mortality Weekly Report (1998) summarized the findings of the follow-up investigation, including a case-control study and an assessment by the county coroner of cases if infant death. This information was important because it provided information about possible health effects related to Stachybotrys fungus.

Gabler, Sager, and Wise (1994) provided basic information about the Köppen classification system. This data was useful because it provides the capability of comparing two or more geographical locations based on temperature and climate. Haughton, Sakamoto, & Gifford (1975) reported general information about Nevada's temperature and climactic conditions.

Bates (1997), Manning (1997b), Dunt (personal communication, 1998, October 6), Couzens (1998a), and Nadler (1998) provided information about Nevada buildings that were confirmed to have Stachybotrys contamination. Stetzenbach (personal communication, 20 July 98, 10 Oct 98, and 16 Oct 98) provided information about fungal analyses of Nevada buildings suspected of containing Stachybotrys contamination. No names or addresses were provided because several of these sites are under litigation. Temperature and pH information was not available for Nevada sites because it was not included in the building analysis process. The provided information from these sources is important because Nevada contamination sites can be compared with other, similar sites around the world that have confirmed Stachybotrys contamination. It also proves that Stachybotrys can and does thrive in the Nevada desert.

Chapter 1 Basic Facts About Stachybotrys chartarum:

Stachybotrys chartarum is classified as a member of the *Hyphomycetes* (Malloch, 1997). It is a macro fungus because it produces spores that can be seen with the naked eye once the colony is firmly established. Johanning describes Stachybotrys as, "…'slimy heads' of watered, *ellipsoidal*, usually black [spores] from clusters of inflated *phialides* [when wet]…" (1997d), and a dull sooty dark brown mass when dry (Deitchman, Martnez, & Upham, 1994).

Stachybotrys is considered a *saprophyte* because its nutrients come from dead or moist decaying organic matter (Deitchman, et al., 1994; Johanning, 1997a). It is not uncommon to find improperly stored cereal, corn, cotton, hay, grain, peanuts, and straw contaminated with Stachybotrys chartarum.

1.1 Growth Requirements:

Water is the most important component needed for Stachybotrys chartarum growth. Chronic leaks, flooded rooms, and areas that are subject to moist conditions, such as those listed in Table 1.1, provide plenty of water to support fungal growth.

Table 1.1 **Moist Areas That Contribute To The Growth Of Stachybotrys Fungus**

Chronic Leaks:	**Flooding:**	**Mists/Vapors/Condensation:**
Plumbing	Basements (carpet & walls)	Air Conditioners/Furnaces
Roofs	Stored Building Materials	Cold Air Return Ducts
Walls	Storage Areas	Humidifiers
		Toilets

Sources: Deitchman, et al., 1994; The American Conference of Governmental Industrial Hygienists (ACGIH), 1989; Johanning, Biagini, Hull, Morey, Jarvis, & Landsbergis, 1996.

In addition to water, Stachybotrys chartarum also needs two primary nutrient sources to survive: a *polysaccharide* called *cellulose* and a low nitrogen content (Croft, Jarvis, & Yatawara, 1986; Pasanen, Nikulin, Berg, & Hintikka, 1994). Both requirements are found in many substances such as ceiling tiles, dust, gypsum board, lint, insulation, paper based products and sheetrock (Johanning, Morey, & Jarvis, 1993a; Pasanen, et al., 1994). Stachybotrys can thrive on these substances if the cellulose materials are wet for a week or more (Dearborn, Smith, & Allan, 1997). Once the fungal spores have a water source and nutrient source, it requires specific environmental conditions to live and grow. Temperature levels, relative humidity levels, and the pH factors are crucial to Stachybotrys survival (Andersson, Nikulin, Koljalg, Andersson, Rainey, Reijula, Hintikka,& Salkinoja-Salonen, 1997; Esswein, Wilcox, & Lonon, 1994; Johanning, 1997b and Croft, et al., 1986).

According to Johanning and his associates (1993b), "[Toxigenic strains of Stachybotrys spores can endure extreme conditions and survive temperatures 30° to 40°C and below 20%RH." This is important because Stachybotrys spores travel long distances, under a wide variety of weather conditions. Sorenson, Kullman, and Hintz (1996) have come to the conclusion that Stachybotrys is a slow growing fungus that sporulates and grows optimally in a pH of 6-7, a temperature of 23°- 28°C, and a relative humidity (RH)of 60% to 100% (Johanning, Morey, & Goldberg, 1993b). Deitchman, et al. (1994 p. 4), stated that, "various strains of Stachybotrys have somewhat different growth requirements; the temperature range for optimum growth is 22° to 27.5°C (72° to 82°F), and the minimum [relative] humidity required for spore germination is 96.3% to 98.5%." An investigation of a St. Croix, Virgin Islands hospital confirmed Stachybotrys chartarum growth in seven rooms. Measured temperatures ranged from 22.6° to 25.3°C (73° - 78°F) in the morning and 22.6° to 26.4°C (73° to 80 °F) in the afternoon, while relative humidity levels ranged from 46% to 73% throughout the day (Esswein, et al., 1994). An investigation in New York City revealed Stachybotrys chartarum growth on the first floor, throughout the basement, and in the subbasement. Measured temperatures at this location in June ranged from 24.4° - 28.1°C with relative humidity levels ranging from 52.6% to 58.3% (Johanning et al., 1996). August readings, during the *remediation* of the subbasement ranged from 21° to 26°C with relative humidity ranging from 64% to 85% (Johanning et al., 1993b). Follow-up readings in November measured temperatures from 22° - 25°C, with relative humidity ranging from 34% to 39% (Johanning et al., 1996).

Pasanen et al. (1994) performed an experiment on respirator filters to determine whether or not Stachybotrys would grow on them. She discovered that Stachybotrys *sporulates* and grows in temperatures between 2 to 40° with relative humidity levels between 78% and 100%, although toxins were not produced with relative humidity between 84% and 89%. Pasanen, et al, (1994) also stated that Stachybotrys produced satratoxin H regardless of variation in temperature when grown in the laboratory under saturated conditions. Table 1.2 compares these studies and summarizes the optimal growth data and extreme survival condition data.

Table 1.2 **Temperature And Relative Humidity Levels**

Published Study	Temperature	Relative Humidity
*St. Croix, Virgin Island (July, 1993)	22.6° to 26.4°C	46% to 73%
New York City (June, initial visit)	24.4° to 28.1°C	52.6% to 58.3%
New York City (August, follow-up visit)	21° to 26°C	64% to 85%
New York City (November, following remediation)	22° to 25°C	34% to 39%
Filter Experiment (laboratory conditions)	2° to 40°C	78% to 100%
✧*Optimal Sporulation And Growth Conditions	22° to 27.5°C	96.3% to 98.5%
❖ Optimal Sporulation And Growth Conditions	23° to 28°C	60% to 100%
◊ Extreme Survival Conditions	30° to 40°C	Below 20%

* Temperature data was converted from °F to °C.
Sources: Esswein, et al., 1994; ❖◊ Johanning et al., 1993b; and Johanning et al., 1996; Pasanen, et al., 1994; ✧Deitchman, et al., 1994

1.2 Dissemination:

Stachybotrys chartarum *dissemination* depends on air currents, physical disturbance, and water incursion (Table 1.3).

Table 1.3 **Stachybotrys Dissemination Mechanisms**

Air Currents:	Vectors:	Water Incursion:
Air Ducts	Insects	Floods
	Humans	Leaks
	Rodents	Heating, Ventilating, Air Conditioning Systems And Circulating Cold Air Ducts
Sources: Yang, 1994; Sorenson, et al., 1996; Croft, et al., 1986		

Stachybotrys chartarum spores do not become airborne easily because they are usually wet and slimy (Yang ,1994; Johanning, et al., 1996). When vectors, such as, insects, rodents (Yang, 1994) or humans, physically disturb the spore mass, the spores become airborne and are transported from one location to another on air currents or through the ventilation system. Johanning (1997b) wrote that, "Mold spores can be airborne, and get indoors through doors, windows or cracks and crevices." Sometimes the spores are physically transported to new locations on the vector's feet, shoes, fur, or clothing.

Water incursion, is another dissemination instrument of Stachybotrys. Fungal spores are carried into the buildings with the water and mud, soaking carpets and furniture, which take a long time to dry out. According to the American Conference of Governmental Industrial Hygienists (ACGIH) (1989, p.6), "Water damaged materials often support *microbial* growth long after they appear dry, and dead materials (spores, *antigens*, toxins, *irritants*) can remain in such materials for years." Sorenson, Frazer, Jarvis, Simpson, & Robinson (1987) found Stachybotrys in carpet samples they analyzed in a 1986 study. It appears that, once the fungi colony is firmly established, it is difficult to eradicate (Esswein, et al., 1994). The ACGIH (1989, p.6) recommends the removal of wet carpet because "…carpet cleaning is rarely effective in removing microbial contamination …and [because] steam cleaning of carpets in place adds water to the environment, which can result in microbial growth."

Here are some examples of water incursion through residential flooding: Montaña, Etzel, Allan, Horgan, & Dearborn (1997) reported that Cleveland, Ohio residents have experienced repetitive flooding due to an overflow cross-connected sewer system and two natural brooks that repeatedly overflowed their banks during heavy rainfalls, flooding several of their homes and businesses. New York City, Manhattan, and Staten Island also suffer from chronic floods in their basements due to the high water table and periodical drain back-ups. (Holloway, 1997a; Holloway, 1997b; Morbidity and Mortality Weekly Report (MMWR), 1998; Scaletta, 1997; Johanning, et al., 1996; Johanning et al., 1993b). Although these cases are isolated flood incursion incidences, it is interesting to note that all four of these cities have reported confirmed cases of Stachybotrys chartarum contamination in these water damaged buildings.

Chronic water leaks are another common type of water incursion. Faulty plumbing and roof leaks are generally found in older, less maintained buildings. According to the Morbidity and Mortality Weekly Report, v.46, n.2 (1997), chronic plumbing leaks or flooding was responsible for the Stachybotrys contamination that was discovered in the homes of all ten case-infants and seven of the 30 control group infants in the study. Heating, ventilating, air conditioning (HVAC) systems and circulating cold air ducts is another place where chronic water leaks can develop. Stachybotrys has also been positively identified in heating, ventilating, air conditioning (HVAC) systems and circulating cold air ducts (Deitchman, et al., 1994; Croft et al., 1986; Johanning, et al., 1996; ACGIH, 1989). These are ideal *habitats* because they provide a moist environment that collects dust, carpet fibers, and lint, which provide all necessary nutrients for fungal growth. Croft and his associates (1986, p. 551) wrote that, "…[due to society's] need to conserve energy, large air conditioned buildings have been effectively sealed to prevent loss of cool air to the outside. Unfortunately, this also seals in the moisture which promotes the growth of undesirable *microorganisms* in the air conditioning units and circulating air ducts." For example, condensation runoff due to improperly insulated supply ductwork was identified as the primary water source for Stachybotrys microbial growth in a northern suburb of a Chicago, Illinois home (Croft, 1996) and in a modular interim hospital in St. Croix, Virgin Islands (Esswein, et al., 1994). Condensation pan overflow is another air conditioning related problem.

1.3 Exposure Routes:

Stachybotrys toxins gain entry into the body through three exposure routes: ingestion, inhalation and skin contact (Johanning, et al., 1993b, Yang, 1994; Deitchman, et al., 1994). Table 1.4 lists possible symptoms that may occur after exposure to Stachybotrys mycotoxin or it's metabolites. Note: The clinical evidence concerning mycotoxins is circumstantial at this time, the mechanisms for these diseases is not completely understood.

Table 1.4 **Possible Symptoms That May Occur After Exposure to Stachybotrys Mycotoxin or it's Metabolites**

Immune system	Skin	Neurological	Digestive system	Vascular	Respiratory
Higher Incidence of Infection	Dermatitis	Toxic Encephalopathy	Nausea	Fragile Blood Vessels and Bleeding	Burning Sore Throat
	Rash	Headache	Vomiting	Nose Bleeds	Irritant Cough

		Memory Problems	Diarrhea	Hemorrhagic Lung Disease	Shortness of Breath
		Verbal Problems	Gallbladder-Like-Colic Pain		Chest Tightness
		Fatigue			Wheezing
		Malaise			Respiratory Tract Ciliary Damage
		Vertigo			Bleeding From the Lungs
		Depression			
Sources: Johanning, 1997d; Johanning, et al., 1996; New York City Department Of Health, New York City Human Resources Administration, Occupational Health Clinical Center, 1993					

According to Pasanen, Nikulin, Tuomainen, Berg, Parikka, and Hintikka, ingestion has been recognized as the main route of mycotoxin exposure (1993). Trichothecene mycotoxins have been linked to numerous cases of toxicosis in farm animals and humans all over the world. Johanning (1996)wrote that, "Stachybotrys chartarum spores usually contain a secondary chemical metabolite called a mycotoxin." Mycotoxins are toxins produced by a fungus. When humans or animals ingest contaminated food or feed, they may suffer adverse health affects, like the disease stachybotryotoxicosis, for example (Croft, et al., 1986; Pasanen, et al., 1993; Deitchman, et al., 1994). Stachybotryotoxicosis has been present in farm animals since the early 1900's in Russia and Europe. According to Deitchman and associates (1994, p.5), "Laboratory studies revealed that the severity of the illness [stachybotryotoxicosis]was dose-dependent and that the trichothecene mycotoxins *elaborated* by the fungi were the responsible agents." Stachybotryotoxicosis is uncommon in humans and is generally not fatal. Only very few, less detailed clinical reports of human cases of stachybotryotoxicosis are available (Johanning, et al., 1993a).

Toxicity can arise from exposure to mycotoxin-containing mold spores through skin contact causing redness and mild swelling to occur at the contact site (Johanning, 1997b). James Craner (personal communication, 1998, November 18) disagrees with Johanning. "There is no conclusive evidence that links direct dermal contact with Stachybotrys to skin irritations.

Skin rashes and other effects appear to be a systemic skin response to mold exposure. The mechanism of this response as with other effects is unclear." Deitchman and associates (1994) related that they knew of reports where the handling of material contaminated by Stachybotrys caused local skin irritation, but it is unknown if systemic effects can occur due to skin absorption.

Inhalation of mold spores is the most common Stachybotrys chartarum exposure route for humans. As stated previously, Stachybotrys chartarum does not become airborne easily (Yang, 1994; Johanning, et al., 1996). It is generally disturbed in its dry state and is then carried through the ventilation system to the rest of the building. Stachybotrys species of fungus have been found at various locations in collected air samples (Sorenson, 1996; Croft, et al., 1986). Respiratory exposure also occurs when people come into close contact with contaminated materials (Deitchman, et al., 1994) such as, farm workers who handle contaminated cereal, cotton, grain, hay, peanuts, and rice (Croft, et al., 1986; Pasanen, et al., 1993). Other high risk occupations include, but are not limited to, textile workers, food handlers, cottonseed oil processors, brewery workers, and grain elevator operators (Sorenson, et al., 1987).

Montaña and associates (1997, p. 1) mentioned an epidemiological study that "…described 30 cases of Idiopathic Pulmonary Hemorrhage (IPH) that occurred over a 20 year period in northern Greece among children ranging from 1 to 6 years of age. This study made the important observation that the cases occurred in household clusters, where many children were sleeping in rooms near stored grain." A similar case was reported in Cleveland, Ohio (MMWR, 1997). According to the MMWR (1997, p. 1), "In November of 1994, private physicians and public health officials in Cleveland, Ohio and CDC (Center for Disease and Control) reported a cluster of eight cases of acute pulmonary hemorrhage/hemosiderosis…[and that] two additional cases were identified in December 1994…These findings documented an association between acute pulmonary hemorrhage/hemosiderosis in this cluster of cases and mold growth in their water-damaged homes." According to Marwick (1997, p. 1342), an "informal surveillance for pulmonary hemorrhage by the CDC following the original report in Cleveland uncovered an additional 32 cases in Ohio and 47 cases among infants in the rest or the country, including 8 in Chicago Illinois". Craner (personal communication, 1998, November 18) cautioned that this study has not been reproduced elsewhere and that many medical and scientific people question the validity and methodology raised by this single case report."

In the study concerning the case in Greece, the original author hypothesized that pesticides was the causational factor involved, whereas, in the Ohio study, the authors eluded to a connection between the presence of Stachybotrys chartarum fungus in the infants homes and their subsequent illnesses. Sorenson (1987, p. 1370) supports the connection between Stachybotrys contamination and the stored grain. He mentioned that, "…the disease [stachybotryotoxicosis] was associated with…dust aerosols heavily laden with conidia in...grain elevators…and other grain processing plants." The children in Greece were sleeping next to Stachybotrys contaminated grain over a long period of time. It is reasonable to conclude that the children may have been exposed to toxigenic fungi via inhalation. Johanning (1996, p. 207, and 1997c, p. 1) believes that, "prolonged and intense exposure to toxigenic S. chartarum and other atypical fungi was associated with reported disorders of the respiratory and central nervous systems" and that, "Exposure to fungi and mycotoxin can, depending on the dose and duration of exposure cause ill health." If the children were exposed to a "significant" amount of toxins, it may account for their illnesses. Unfortunately, scientists do not know what a "significant amount" is. Dose/response criteria and exposure contact time was not reported anywhere in the reviewed literature. No regulations exist that set limits of exposure for

Stachybotrys or other types of bioaerosols. The American Conference of Governmental Industrial Hygienists did write a set of guidelines for the assessment of bioaerosols in the indoor environment. These guidelines outline methods for: medical preassessment, on-site investigations, and recommendations for: air sampling, remedial actions, biocides, viruses, bacteria, endotoxin, fungi, mycotoxins, protozoa, and antigens (ACGIH, 1989). See Table 1.5 for additional symptoms of pulmonary hemosiderosis and/or stachybotryotoxicosis.

1.4 Experimental Toxicity, Measurement Limitations, and Health Effects:

Stachybotrys chartarum is one of several deuteromycete fungi thought to produce *trichothecene mycotoxins* including *macrocyclic* trichothecenes, *satratoxins* F, G, and H, *roridin* E, and Verrucarrin J and trichoverrols A and B (Sorenson, et al., 1987; Pasanen, et al., 1994). Trichothecenes are secondary metabolites of Stachybotrys chartarum and a toxin that has been found in *respirable* spores. It is important to note that clinical toxicity data with regard to human toxicological response is relative scarce.

Croft, et al. (1986), Johanning, et al. (1993a) and Esswein, et al. (1994) believe that some strains of Stachybotrys chartarum trichothecenes can affect the human immune system causing hemorrhagic gastroenteritis and *acute systemic toxemia* if ingested, as well as severe *dermatitis* if allowed to contact skin or mucus membranes. They also believe that Stachybotrys chartarum can, under certain environmental conditions, produce trichothecene mycotoxins, like cytotoxin. Cytotoxins have been identified in cases of human and animal *toxicosis* and death. Satratoxin H is a potent cytotoxin and can inhibit protein synthesis and has also been found to cause *immuno-suppression*. Nikulin, Reijula, Jarvis, & Hintikka (1996) tested mice to investigate lung mycotoxicosis. One group of mice received one intranasal injection of a toxic strain of Stachybotrys and the other group a less toxic strain. The highly toxic strain contained trichothecene mycotoxins, satratoxins. The severity of the lung damage caused by the two strains of Stachybotrys was significantly different. The spores containing satratoxins caused severe intra-alveolar, bronchiolar and interstitial inflammation with hemorrhagic exudative processes in the alveolar and bronchiolar lumen. The spores without satratoxins induced a milder inflammation, so that the toxic compounds of Stachybotrys-spores are most likely responsible for the severity of the lung injury.

Toxins are generally found in the conidia, or spores, of fungi (Esswein, et al., 1994; Johanning, 1997a). However, not all metabolites of Stachybotrys are toxic. Croft (1986, p. 551) tested a sample of the Stachybotrys isolate he found on some paintings in his basement and discovered that it was not toxic. He reported that, "Various *isolates* of S. atra differ greatly in their toxigenic properties…[and that]…other isolates of S. atra appear unable to produce these toxins, at least under laboratory conditions." Pasanen et al., (1994), while experimenting on respirator filters, also noted that Stachybotryotoxins were not produced when relative humidity levels were between 84% and 89%.

Many researchers commented that evaluating the organism(s) responsible for causing the recognized health problems was an extremely difficult task because the environmental samples they were working with did not always reflect the true population of the fungal community at the contaminated site (Croft, et al., 1996). The samples were invariably contaminated by a variety of microorganisms, including Stachybotrys chartarum. Scientists found that laboratory isolation of the microorganisms from the sample often selects the faster growing organisms, and populations of organisms (Croft, et al., 1996). "Only a small percentage of the Stachybotrys, conidia are usually viable in laboratory cultures, their growth is inhibited by several species of Penicillium… dominance of the slow growing S. chartarum on mold populations growing on the interior building material may indicate the presence of an old and stable microbial community" (Andersson, 1997, p. 392).

Experts recommend a multi-sampling method be used when testing for Stachybotrys contamination because air sampling techniques do not always reflect the true microbial population. In many cases air sampling failed to show Stachybotrys contamination at all even though surface sampling revealed its presence. Esswein, et al. (1994, p. 13) wrote, "The point that must be made is that regardless of the air sampling results, the presence of visible and disseminated fungal and bacterial contamination in the hospital pose increased risk factors for public health and the health of the hospital staff."

Mycotoxins may cause a variety of adverse health effects including, immediate toxic response, immune suppression, or an impaired or altered immune system. Other symptoms include recurring cold and flu-like symptoms, a burning sore throat, headache, excessive fatigue and diarrhea. "Long term risk and clinical prognosis of toxigenic fungal inhalation, particularly S. chartarum and its mycotoxins, in humans is not well known" (Johanning, et al, 1996, p. 217). Many researchers believe these symptoms are due to exposure to Stachybotryotoxins. "Individuals with persistent health problems should be referred to practitioners trained in occupational/environmental medicine or related specialties and knowledgeable about these types of exposures" (NYC-DOH, et al., 1993, p. 2).

1.4.1 Target Organs:

Macrocyclic trichothecene toxins produced by Stachybotrys may exhibit potent toxicity to humans and animals. Target organ systems include the brain, immune system, heart, lung, intestine, liver, kidney and skin (Croft, et al., 1986). Johanning (1996 and 1997d) believes that prolonged exposure to Stachybotrys and other indoor atypical fungi can have an immunotoxic affect because individuals who were exposed the toxins experience higher incidences of infection, increased immune reactivity, and possibly impaired immunity. It can also have dermal effects because the toxins may irritate the skin. Some researchers believe that Neuro-cognative effects may be the result of mycotoxins damaging or destroying nerve tissue, however, the mechanism that causes Neuro-cognative impairment has not been positively identified. Symptoms include: difficulty concentrating (shortened memory), mood swings (irritability), and personality changes. Digestive system effects result from mycotoxins damaging or irritating intestine cells. Mycotoxins may also effect the vascular system by weakening the blood vessels to the point where they become fragile and break. Damage to the respiratory system (the lungs) manifests itself through symptoms like: shortness of breath, chest tightness, coughing, throat irritation (hoarseness), congestion and possibly bleeding from the lungs. Table 1.4 lists additional symptoms of these disorders (Johanning, 1996; Johanning, 1997d; Craner, personal communication, 1998, November 18).

1.4.2 Diseases:

Prolonged and intense exposure to toxigenic Stachybotrys chartarum may produce fatal results. Table 1.5 lists three Stachybotrys chartarum related diseases and their symptoms: pulmonary hemosiderosis, stachybotryotoxicosis, and pulmonary mycotoxicosis.

Table 1.5 **Stachybotrys-related Diseases And Possible Symptoms**

Symptoms	Pulmonary Hemosiderosis	Stachybotyryotoxicosis	Pulmonary Mycotoxicosis
Abdominal Pain		⌘	
Anemia	⌘		
Chest Congestion	⌘		
Chest pain		⌘	
Chest Tightness			⌘
Chills			⌘
Chronic Cough	⌘		⌘
Cyanosis		⌘	
Diarrhea		⌘	
Dizziness		⌘	
Dry Cough		⌘	⌘
Dyspnea			⌘
Fever		⌘	⌘
Headache		⌘	⌘
Hemorrhage (mucus membrane or gastrointestinal tract)		⌘	
Immune System Suppression		⌘	
Malaise			⌘
Myalgia			⌘
Nose Bleeds	⌘		
Perechiae		⌘	
Pulmonary Hemorrhage	⌘		
Sepsis		⌘	
Skin Necrosis		⌘	
Sweating		⌘	
Tachycardia		⌘	
Vomiting		⌘	
White Blood Cell Increase			⌘
Weakness		⌘	

Sources: Deitchman, et al., 1994; Centers for Disease Control and Prevention (CDC), U. S. Department of Health and Human Services, 1996.

Pulmonary hemosiderosis is a disease that involves bleeding of the lungs. Stachybotrys chartarum has been linked to this disease because investigators in Cleveland, Ohio "… found a clear correlation between the presence of fungi, including S. atra, in the homes of the affected infants compared with the control infants" (Marwick, 1997, p. 1342). Table 1.5 lists pulmonary hemosiderosis symptoms. As previously mentioned, Craner (personal communication, 1998, November 18) believes that many medical and scientific people question the validity and methodology raised by this single case report because the study has not been reproduced elsewhere.

Stachybotryotoxicosis has been long recognized as a disease which affects farm animals. The disease is contracted after the animal has eaten moldy grain or hay (Croft, et al., 1986; Pasanen, 1993; Deitchman, et al., 1994). "Only a few, less detailed, clinical reports of human cases of stachybotryotoxicosis are available. It was thought that mainly farm workers and laboratory personnel (military and food safety research labs) belong to the high risk group of mycotoxin related diseases" (Johanning, et al., 1993a, p. 228). Table 1.5 lists stachybotryotoxicosis symptoms.

Pulmonary mycotoxicosis is an occupational illness sometimes suffered by people who are exposed, via inhalation, to heavy concentrations of fungi dust particles in farm silos. Table 1.5 lists pulmonary mycotoxicosis symptoms.

1.5 Location:

Geographically, Stachybotrys has been found all over the world (Pasanen, et al., 1994; Deitchman, et al., 1994), including: Canada, Greece, the Ukraine, and the United States. Each of these locations has various climates and temperature ranges that can change as a result of elevation and seasonal changes. The KÖpen classification system, developed in 1918, consists of five basic climatic realms which are symbolized by capitol letters A through E. These regions are further broken down into seasonal distributions of rainfall and the degree of summer heat and winter cold (Haughton, Sakamoto, and Gifford, 1975). Table 1.6 introduces the KÖpen classification system climate designations and its corresponding geographical regions and weather conditions.

Table 1.6 **KÖpen Classification System Climate Designations, Locations And Weather Conditions**

Symbol	Climate	Region	Weather Conditions
l AW	Humid Tropical	Tropical Savanna	Coolest month is <18°C (64.4°F) No Winter
BSH	Arid	Steppe	Mean Annual Temperature is<18°C (64.4°F)
BSK	Arid	Steppe	Mean Annual Temperature is >18°C (64.4°F)
BWH	Arid	Desert	Mean Annual Temperature is<18°C (64.4°F)
CFA	Humid Mesothermal	Humid Subtropical	Warmest month Above 22°C (71.6°F) Driest month Has At Least 6 cm Rain (2.4 in.)
CSA	Humid Mesothermal	Mediterranean	Warmest month Above 22°C (71.6°F)
CSB	Humid Mesothermal	Mediterranean	Warmest month Above 22°C (71.6°F) With 4 Months Above 10°C (50°F) & Coldest Months Below -38°C (-36.4°F)
DFD	Humid Microthermal	Subarctic	Warmest month Below 22°C (71.6°F) With 1-3 Months Above 10°C (50°F) Driest month Has At Least 6 cm Rain (2.4 in.)
DFA	Humid Microthermal	Humid Continental Hot Summer	Warmest month Above 22°C (71.6°F) Driest month Has At Least 6 cm Rain (2.4 in.)

l The symbols are climate designations from the Köpen classification system. Not abbreviations or acronyms
Source: Gabler, et al., 1994

This information can be used to identify the regions where Stachybotrys has been identified and to compare the locations to see if there are similarities between the geological locations. Table 1.7 depicts the geographical areas where Stachybotrys contamination has been reported, and it classifies those locations by climate using the Köpen classification system.

Table 1.7 **Geographical Locations And Climates Where Stachybotrys Has Been Found.**

	l AW	BSH	BSK	BWH	CFA	CSA	CSB	DFA	DFD
CANADA									
QUEBEC	❖	❖							
GREECE						❖	❖		
UKRAINE			❖						❖
UNITED STATES									

CALIFORNIA				❖					
FLORIDA					❖				
ILLINOIS								❖	
MICHIGAN								❖	
NEVADA			❖	❖					
NEW YORK								❖	
OHIO									❖

Note: See Table 1.6 for a definition of the climate designations: AW, BSH, BSK, etc.
l The symbols are climate designations from the Köpen classification system. Not abbreviations/acronyms.
Sources: MMWR, 1997; Scarletta, 1997; Montaña, et al., 1997; Johanning et al., 1996; Esswein, et al, 1994; Deitchman, 1994; Yang, 1994; Gabler, Sager, & Wise, 1994; Johanning et al., 1994 and Croft et al., 1986.

1.6 Contaminated Sites:

Stachybotrys can and does grow in any location that provides the right environmental conditions. I found that most of the Stachybotrys contaminated sites had high relative humidity levels, moisture problems with HVAC, systems and structural leaks in conjunction with heavy rains. Other areas that reported high incidences of Stachybotrys growth were areas prone to flooding like lakes, rivers, overflow channels, and high water tables, for example. Table 1.8 lists the geological locations where Stachybotrys growth was reported and prevalent moisture sources. Table 1.9 matches a list of specific sites where Stachybotrys chartarum has been positively identified, along with the geographic area in which it was located.

Table 1.8 **Geological Locations And Moisture Sources Related To Stachybotrys Growth.**

Geographic Location	Flooding	High Water Table	Ductwork	Plumbing and Roof Leaks	High Relative Humidity
Atlanta, Georgia	*	*		*	*
Chicago, Illinois			*	*	
Grand Forks, Michigan	*				
Las Vegas, Nevada	*		*	*	
Manhattan, New York	*	*			*
New York City, New York	*	*			*
Staten Island, New York	*	*			*
Cleveland, Ohio	*				
Asia					*
Canada				*	
Europe				*	*
Greece					*
Russia					*
St. Croix, Virgin Islands			*	*	*

Sources: MMWR, 1997; Scarletta, 1997; Marwick, 1997; Montaña, et al., 1997; Johanning et al., 1996; Esswein, et al, 1994; Deitchman, et al., 1994; Yang, 1994; Johanning et al., 1993b; Croft et al., 1986

Table 1.9 **Specific Sites And Geographic Locations Where Stachybotrys Chartarum Has Been Found**

Residential Homes	**Hospitals**	**Schools**	**Offices**	**Storage Areas**	**Libraries**	**Farms**
Cleveland, Ohio	St. Croix, Virgin Islands	Canada	New York City	Greece	New York City	Ukraine
Grand Forks, Michigan	Atlanta, Georgia	Grand Forks, Michigan	Atlanta, Georgia	Atlanta, Georgia	Staten Island, New York	Russia
Chicago, Illinois		Staten Island, New York	Las Vegas, Nevada			Europe
Manhattan, New York		Las Vegas, Nevada				Asia
Las Vegas, Nevada						

Sources: Stetzenbach, personal communication, 1998, October 16; MMWR, 1997; Scarletta, 1997; Montaña, et al., 1997; Johanning et al., 1996; Esswein, et al, 1994; Deitchman, et al., 1994; Yang, 1994; Johanning et al., 1993b; Croft et al.,1986

Stachybotrys can thrive in many different climates. This may be due to the fact that some strains of Stachybotrys can withstand intense temperature fluctuations and still remain unaffected. Pasanen and associates conducted several experiments to determine whether or not

Stachybotrys fungi could grow on filters. Not only did they discover that it did grow on filters, they learned that the production of Stachybotryotoxins did not seem to be affected by the rapid decrease of temperature, 20-23°C to 6-8°C (1994).

Chapter 2 Stachybotrys chartarum in Nevada

2.1 Geographic Location, Temperature and Precipitation:

According to Houghton, Sakamoto, and Gifford (1975), Nevada spans a full 7 degrees of latitude from 35° to 42° N. Southern Nevada is subtropical, and the temperature in northern and central Nevada are typical of the middle latitudes. Elevation differences reinforce this effect, because the land averages 2,000 to 3,000 feet higher in the north than in the south. Temperatures average 15° to 20° F cooler in Elko, Ely, and Reno than they do in Las Vegas.

Pasanen et al. reported that Stachybotrys atra sporulates and grows in temperature s ranging from 2 to 40°C. Nevada has temperatures that fall well within this temperature range. The majority of Nevada residences are climate controlled due to extreme summer temperatures. Most thermostats are fixed between 19.8 ° and 22°C (68°-72°F). Deitchman, et al, stated that temperatures between 22°C to 27.5° are ideal for Stachybotrys sporulation and growth.

According to the Köpen Classification System, Nevada has five climate designations: Humid continental (DFA), Subhumid continental (DFB), Mid-latitude steppe (BSK), Mid-latitude desert (BWK), and Low-latitude desert (BWH). Table 2.1 lists these designations along with mean temperatures for winter and summer months, annual precipitation in inches, and dominant vegetation types.

Table 2.1 **Köpen Classification System Climate Designations, Vegetation And Weather Conditions For Nevada**

Climate	Symbol	Mean temperature (F°) Winter	Summer	Annual Precipitation (inches) Total	Snowfall	Dominant vegetation
Humid continental	I DFA	10-30°	50-70°	25-45"	Heavy	Pine-fir forest

Subhumid continental	DFB	10-30°	50-70°	12-25"	Moderate	Pine or scrub woodland
Mid-latitude steppe	BSK	20-40°	65-80°	6-15"	Light to moderate	Sagebrush, grass, scrub
Mid-latitude desert	BWK	20-40°	65-80°	3- 8"	Light	Greasewood, shadscale
Low-latitude desert	BWH	40-50°	80-90°	2-10"	Negligible	Creosote brush

Note: See Table 1.6 for a definition of the climate designations: AW, BSH, BSK, etc.
l The symbols are climate designations from the Köpen classification system. Not abbreviations or acronyms. Sources: Gabler, et al., 1994; Houghton, et al., 1975

The climate designations: Humid continental (DFA), Mid-latitude steppe (BSK), and the Mid-latitude desert (BWK) have temperature ranges that favorably support Stachybotrys chartarum growth. Several other geological locations that have confirmed Stachybotrys contamination in their water damaged homes have the same climate designation classifications as Nevada. Illinois, Michigan, and New York have a humid continental (DFA) climate. Illinois and New York also have mid-latitude desert (BWK) climates, and the Ukraine has a mid-latitude steppe (BSK)climate. Just because we live in a desert does not mean that we do not have conditions that are conducive to fungal growth. Table 2.2 summarizes these geographical locations and climate designations.

2.2 Climate Locations and Growth Requirements:

Table 2.2 **Comparison Of Nevada And Other Similar Geographical Climates Where Stachybotrys Was Found.**

	BSK Mid-latitude Desert	**BWH Low-latitude Desert**	**DFA Humid Continental**
UKRAINE	❖		
UNITED STATES			
CALIFORNIA		❖	

ILLINOIS			❖
MICHIGAN			❖
NEVADA	❖	❖	❖
NEW YORK			❖
Source: Scaletta, 1997; Croft et, al., 1986; CDC, 1996; Johanning et al., 1996; Johanning et al., 1993a			

According to Linda Stepzenbach (personal communication, 20 July 98, 10 Oct 98, and 16 Oct 98), the Director of the Microbiology Division, Harry Reid Center for Environmental Studies, UNLV, plumbing leaks are the number one cause of Stachybotrys proliferation in Nevada. These leaks, when left unattended, provide a continuous water source for fungal growth. The Grant Sawyer State Office Building in Las Vegas, Nevada is a good example of a building that had a long history of plumbing leaks and ductwork condensation problems that were not immediately repaired. It led to wide spread Stachybotrys contamination. According to Craner (personal communication, 1998, November 18) "a visual inspection finally revealed a significant number of ceiling tiles and several walls that had visible staining from previous water leakage. Many of the stained areas had visible evidence of actual fungal growth on the plenum or non-occupant side. The tiles and walls were all located immediately underneath the hot water valves of the VAV (variable air volume) boxes. Some of these had been previously painted over to hide the stains.

Roof leaks are the 2nd cause of Stachybotrys proliferation in Nevada. Many of Nevada's older buildings have flat roofs, allowing water to accumulate and then seep down through the walls (Stetzenbach, personal communication, 1998, October 16). Building maintenance is crucial to controlling fungal growth in both of these situations.

Flooding is the 3rd cause of Stachybotrys proliferation in Nevada. Las Vegas has two clearly defined rainy seasons: winter and summer. Winter storms are low-rain intensive frontal storms, whereas summer storms are generally caused by violent, high-rain intensive, thunderstorms resulting from warm, moist, tropical air. According to the United States Department of Agriculture, Soil Conservation Service (1977), nearly one-third of Nevada's average annual precipitation occurs as short term, high-intensity, localized (small area) rainfall which is deposited within the first five or ten minutes of the thunderstorm. Normally the duration of these storms is less than one hour; however they often result in flash floods. Table 2.3 is a select listing of major flood events in Clark County, Nevada. The table includes the flood dates, the amount of rainfall in inches and the reported damage estimates. In addition, Appendix A lists Clark County's flood history from 1905 to 1975 based on a review of newspaper accounts obtained the Nevada State Library in Carson City.

Table 2.3 **Summary Of Historical Floods (Clark County, Nevada)**

Date	Precipitation (inches)	Damage Estimates
July 23, 1923	1.98	$25,000
August 12, 1931	2.74	Not determined
February 1, 1940	0.74	Not Recorded
August 9 - 10, 1942	1.75	Minor report of damage
October 12, 1947	1.04	$100,000
July 31, 1949	0.7 - 0.52	$10,000+
September 28, 1951	0.98	Minor
July 25, 1954	1.18	Unknown
June 13, 1955	0.39 - 3	$1.5 - 3 million
July 24, 1955	1.29 - 1.9	$200,000
August 21, 1957	2.57	$50,000
September 16, 1961	0.09	$500,000
September 4, 1963	0.80	Minor
September 16, 1959	0.48 @ Little Rock	$250,000
July 3 - 4, 1975	.22 - 3	$4 - 5 million

Source: United States Department Of Agriculture, Soil Conservation Service, 1979

Not only does flooding provide the necessary water for Stachybotrys chartarum growth, it also provides the transportation means for the spores to move to new locations through flood water and mud.

2.3 Contaminated Sites, Sample Media, and Health Effects:

The following geographical locations have confirmed Stachybotrys chartarum contamination as a result of floodwater damage: Atlanta, Georgia; Chicago, Illinois; Cleveland, Ohio; Grand Forks, Michigan; Manhattan, New York; New York City, New York; and Staten Island, New York. Nevada has also incurred water damage through flooding. Altine and Dunn (1997) reported that, during the Great Flood in January 1997, along the Truckee River, Nevada residents had to clean floodwater and mud out of their businesses and homes. "In the Truckee Meadows, residents are knee deep in mud as they clean up homes and businesses" (Altine, et al., 1997). The Truckee river was not the only Nevada river to flood; up to 500 homes and businesses in Yerington were submerged in the Walker River floodwaters (Altine, et al., 1997). The Great Flood of 1997 enveloped Carson City, Douglas, lyon, Storey, and Washoe Counties.

On August 10, 1997, more than three inches of rain fell in Henderson and Boulder City, causing an overflow of water in culverts, washes, and roadways (Puit, 1997). The American Red Cross reported that, 14 single-family homes in Clark County suffered major damage and fifty-eight homes had minor damage, as did 23 mobile homes and 25 apartments (Whaley, 1997). Doerte Hoentsch told Glenn Puit (1997, p.2), that, " In the last 30 years, her house has flooded 6 times." The flood ruined Doerte's carpets and, stained her walls, and the smell of mildew pervaded the house. On September 4, 1997, several homes and schools in Pahrump, Nevada were flooded when 5.2 inches of rain fell in 3.5 hours (Bates, 1997). Flash floods are a fact of life in Nevada. Fungal problems start when water gets into homes and businesses.

According to Thomas McManus, a Las Vegas industrial hygienist, water damage must be take care of right away - within 24 hours and no more than 48 hours (Nadler 1998). Dr. Stetzenbach (personal communication, 1998, October 16) added that, depending on environmental conditions, Stachybotrys can take between two days and two weeks to accumulate fungal levels that can be seen.

In 1997, the Harry Reid Center, microbiology staff at UNLV were asked to test 43 Clark County buildings for Stachybotrys contamination as a preventative measure because they incurred some type of water damage. 23 of the 43 buildings analyzed tested positive.

In 1998, 54 buildings were analyzed and 16 tested positive (Stetzenbach, personal communication, 1998, October 16). Most locations that were analyzed were State and Federal buildings. The Clark County School District also asked Dr. Stetzenbach to advise them about renovating 23 water damaged schools. Currently, all of those school have been repaired (Nadler, 1998). According to Stetzenbach (personal communication, 1998, October 16), residential homes are rarely analyzed because the test costs$1,000; however, Craner (personal communication, 1998, November 18), mentioned that he found Stachybotrys-related problems in approximately 15 homes. Table 2.4 lists the sites where Stachybotrys chartarum contamination was confirmed in Nevada by year and location.

Table 2.4 **Specific Sites and Nevada Locations Where Stachybotrys Has Been Confirmed**

	Residential Homes	**Classrooms**	**Office Buildings**	**Storage Areas**
Clark County				
1997	6	5	12	
1998	7	3	6	
Carson City				
1998			1	1

* This information is not all inclusive

Sources: Dunt, persona communication, 1998, October 06 and Stetzenbach, personal communication, 1998, October 16; and Manning, 1997

During an interview on October 16, 1998, Dr. Stetzenbach said she could not name specific Stachybotrys contaminated buildings because many of the cases are under litigation (see Tables 2.4 and 2.5). Obtaining information about Nevada buildings was difficult. Several newspapers reported a few specific examples of Stachybotrys contaminated buildings in Clark County, Nevada. Other sources confirmed the reports.

The Grant Sawyer State Office Building in Las Vegas, Nevada was confirmed to have Stachybotrys contamination (Dunt, personal communication, 1998, October 06; Couzens, 1998a). It started in early 1995 with several employee complaints that the air smelled fowl and that the building occupants were experiencing a multitude of illnesses including: headaches, nausea, respiratory problems, skin rashes, mucous membrane inflammation, and other sicknesses that disappeared once they left the building (See Tables 1.4 and 1.5 for Stachybotrys-related symptoms). Several attempts were made to determine what was causing these illnesses. Craner (personal communication, 1998, November 18) concluded, "The results strongly suggest that the building-related health

> complaints are most likely attributable to fungal contamination on ceiling tiles and walls from leaking VAV hot water valves and possibly other leaking pipes. The presence of specific strains of fungi growth (or presence of recent growth) on ceiling tiles and walls in most, if not all, of the areas where occupants have reported building-related illness appears to be the most significant, biological, and medically plausible explanation of the building's IAQ (indoor air quality) complaints. The types of fungi dedicated in the Sawyer Building are capable of causing human illness seen in 'sick building syndrome'."

"The fungus [Stachybotrys]was also found in the Employment Security Office at Eighth Street and Carson Avenue, in May, 1997. Employees were evacuated after the spores were captured in the air" (Manning, 1997b, p. 1). According to Ted Ice, environmental manager for the State Public Works Board, "Water was draining from the roof into the building…and plumbing on the second floor was leaking badly. Mold was growing on ceilings and down several walls" (Nadler, 1998, p. 5A). The structure was demolished in July after several of the 60 employees began complaining of respiratory problems (Nadler, 1998; Bates, 1997). The Eighth Street employees were moved to the state Employment Office in North Las Vegas.

The state Employment Security Office in North Las Vegas was also confirmed to have Stachybotrys contamination. Employees noticed bulging wallboard which led to the fungal discovery. Industrial Hygienist, Dr. George Tkaczuk said there was no danger to the employees because the contaminated areas were not connected to the building ventilation system. Several building occupants have visited their doctors complaining of flu like symptoms (Manning, 1997a; Manning, 1997b). The structures inside walls but it was repaired and the building now has a clean bill of health (Couzens, 1998; Nadler, 1998). Table 2.5 summarizes the media that was sampled for Stachybotrys chartarum contamination. The numbers represent positive confirmation of Stachybotrys contamination on the tested media.

Table 2.5 **Sample Media And Number Of Stachybotrys Contamination Incidences**

	Plumbing: Wallboard	Plumbing: Ceiling Tile	Roof Leak: Wallboard/ * Painted Wall	Roof Leak: Ceiling Tile	Flood: Wallpaper/ Wallboard	Air Sample	Air Filter	Total Buildings Sampled
Clark County								
1997	10	2	4	4	1	8	2	43
1998	8	0	5	3	0	5	0	54
Carson City								
1998	0	0	* 1	1	0	0	0	2

Source: Dunt, persona communication, 1998, October 06 and Stetzenbach, personal communication, 1998, October 16

The sample media is identical to that found in other locations throughout the world.

DISCUSSION

This list of contaminated sites listed in Table 2.4 is not all inclusive. Manning (1997a, p. 2) wrote "As the Las Vegas Valley becomes more urbanized, the fungus is becoming more common, health experts say." As previously mentioned, Craner (personal communication, 1998, November 18) found fungal problems in approximately 15 residential homes. He also said that many physicians mistake reactions to building problems as bronchitis and wrongly prescribe antibiotics. Health professionals and consultants need to include the possibility that their patients' respiratory problems may stem from exposure to mycotoxins in the work place or at home. Situations where moisture damage has occurred is often overlooked as the cause of adverse health.

The assumption is that since Nevada is a desert, fungi cannot survive here or become problematic. All evidence is to the contrary. Nevada and other locations throughout the world are beginning to see a correlation between water damaged structures and adverse health. Conditions in Nevada are sufficient for Stachybotrys sporulation and growth. Plumbing, air conditioning and roof leaks may provide the most necessary component needed for fungal growth - water. Dr. Stetzenbach said that the number one water source for Stachybotrys growth in Nevada is plumbing leaks. In older neighborhoods, flat roofs are commonplace and can be a problem. Water tends to pool on the roofs and then leaks down into the walls.

Nevada also has an active flood history. This is a twofold problem because Stachybotrys chartarum spores can be disseminated in floodwater and mud, depositing in peoples homes, while, at the same time, providing the necessary water component needed for fungus sporulation and growth.

Research shows that **s**ome strains of Stachybotrys chartarum are more toxic than others. Some metabolites are not toxigenic, although environmental conditions play an important role in determining how toxic or non-toxic the spores will be. Research has also shown that several species of fungi may grow together. It is unknown whether or not other bioaerosols and fungi have a synergistic affect on human health. Strong epidemiological evidence supports the conclusion that Stachybotrys and its' metabolites are linked to poor human health. Therefore, it is very important to use sampling methods that are capable of detecting Stachybotrys contamination because other species of fungi can inhibit the slower growing Stachybotrys under laboratory conditions. Only a fraction of Stachybotrys spores are viable in laboratory cultures. Single method sampling may be inadequate to determine if Stachybotrys is present at a suspected contaminated site. A multimethod approach should be used when collecting and analyzing microbial samples because it has a higher detection rate.

In conclusion, throughout my extensive research into this study, three items became clear. First, Stachybotrys must have proper environmental conditions to survive, although the spores can survive extreme conditions in the dissemination process. Second, Stachybotrys has been found consistently in water-damaged buildings throughout the world. Evidence has demonstrated that Stachybotrys has caused several diseases in animals, who ate contaminated feed for thousands of years, and it is only recently that scientists have been able to link Stachybotrys to human illnesses, albeit controversially. Third, the majority of adverse health complaints have consistently coincided with the discovery of Stachybotrys chartarum growth in their water-damaged buildings. The evidence is clear. Stachybotrys can and does thrive in the Nevada desert, and if toxigenic exposure occurs in high enough concentrations, Nevada residents may become ill. Just because we live in the desert does not mean that we do not have fungi problems. Medical professionals and consultants should consider microbial contaminants in their assessment of their patients because there is a potential risk that Nevadans may have been exposed to Stachybotrys and its metabolites.

GLOSSARY

ACGIH- American Conference of Governmental Industrial Hygienists

acute- Reaching a crisis rapidly; Extremely severe or sharp.

antigens- Recognizable proteins used by the immune system to distinguish between "self" and "nonself." They are often surface recognition features on cells.

cellulose- A complex carbohydrate, $(C_6H_{10}O_5)_n$, that is composed of glucose units that forms the main constituent of the cell wall in most plants**.**

cellulolytic- Hydrolyzing or having the capacity to hydrolyze cellulose.

conidiophore- A simple or branhed hypha bearing or consisting of conidiogeneous cells from which conidia are produced.

cytotoxic- Of, relating to, or producing a toxic effect on cells.

cytotoxin- A substance having a specific toxic effect on certain cells.

dissemination- To spread widely; Distribute.

dermatitis- Inflammation of the skin.

elaborated- To work out with care and detail; develop thoroughly.

ellipsoidal- A geometric surface whose plane sections are all ellipses or circles.

eucaryotic- An organism composed of one or more cells with visibly evident nuclei.

habitat- Location within an ecosystem occupied by a particular organism.

hyphomycetes- Mitosporic fungi.

immunosuppression- Tending to suppress a natural immune response of an organism to an antigen.

irritant- Something that causes irritation.

isolate- To separate from a group or whole and set apart.

macrocyclic- Rust fungi.

metabolites- To subject (a substance) to metabolism; To produce (a substance) by metabolism.

microbial- A minute life form; microorganism.

microorganism- A plant or animal of microscopic size.

mycotoxins- A toxic substance produced by a fungus.

pH- **A** measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. [p(otential) of H(ydrogen).]

phialide- A cell that develops one or more open ended conidiogeneous loci from which a basipeta succession of conidia, phialospores develops without an increase in length of the phialide itself.

phytotoxtic- Poisonous to plants.

polysaccharide- A group of nine or more monosaccharides joined by bonds such as starch or cellulose.

remediation- To restore to a previous state.

respirable- Inhalable.

roridin- A trichothecene mycotoxin, similar in structure to the verrucarins.

saprophyte- A plant that grows on dead or decaying organic matter.

saprobe- An organism that derives its nourishment from nonliving or decaying organic matter.

satratoxin- Toxins of Stachybotrys atra; the cause of stachybotryotoxicosis in farm animals and humans.

sesquiterpene- **A**ny class of terpenes $C_{15}H_{24}$; a derivative of such a terpene; Used in organic synthesis - from conifers.

sporulate- To disperse seeds.

systemic- Pertaining to a system or systems; Of, relating to or affecting the entire body

toxemia- A condition in which toxins produced by body cells at a local source of infection are contained in the blood.

toxicosis- Poisoning; the state or quality of being poisoned.

toxin- A substance produced by a plant, animal, or microorganism, that has a protein structure and is capable of causing poisoning when introduced into the body but is also capable of stimulating production of an antitoxin.

trichothecenes- Any of a class of more than 40sesquiterpenoid mycotoxins produced by a variety of fungi that grows cheifly in grains.

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APPENDIX A

Table A-1 **Summary Of Recorded Flood Events By Month And Year: Clark County, Nevada, 1905 - 1975.**

Summary Of Recorded Flood Events In Clark County, Nevada, 1905 - 1975 By Month And Year

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1905							1						1
1906			1					1					2
1907			2										2
1908								1					1
1909								1					1
1910	1												1
1911	1		2										3
1912								1					1
1913													0
1914		2					1						3
1915													0
1916	1									1			2
1917					1			1					2
1918			1										1
1919							1						1
1920							1						1
1921								1					1
1922	1							1					2
1923							2						2
1924													0
1925								1	1				2
1926							2						2
1927		1						1			1		3
1928								1					1
1929								2	2				4
1930								1					1
1931							1	2					3
1932		1					2	2					5
1933								2					2
1934	1							1					2
1935									1				1
1936							1	1					2
1937			1						1				2
1938			1			2		1					4
1939				1					4				5
1940		1											1
1941			1					1					2
1942								2					2
1943													0

*** NOTE: Table A-1 continues onto the next page. *Table is for reference only**

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1944													**0**
1945							**1**	**1**					**2**
1946							**1**			**1**			**2**
1947										**1**			**1**
1948													**0**
1949								**1**					**1**
1950									**1**				**1**
1951													**4**
1952							**1**	**2**	**1**				**5**
1953													**0**
1954			**1**			**1**	**2**		**2**				**6**
1955						**3**	**2**	**1**					**6**
1956							**4**						**4**
1957							**2**	**2**					**4**
1958						**1**	**1**		**1**		**1**		**4**
1959								**4**					**4**
1960							**1**		**2**		**1**		**4**
1961				**1**			**3**	**4**	**1**				**9**
1962			**1**										**1**
1963									**1**				**1**
1964													**0**
1965			**1**	**2**			**1**						**4**
1966							**1**		**1**				**2**
1967						**1**	**1**	**3**	**2**				**7**
1968							**1**						**1**
1969	**1**					**1**			**1**				**3**
1970								**3**					**3**
1971								**2**					**2**
1972								**2**					**2**
1973			**1**			**1**		**1**					**3**
1974							**3**		**1**	**3**			**7**
1975		**1**	**1**				**1**	**1**	**1**				**5**
Total 1905 - 1975	**6**	**6**	**15**	**4**	**1**	**10**	**40**	**52**	**26**	**5**	**3**	**1**	**169**

*Period 1905-1946 - Newspaper accounts for each month for each tear were scanned.
*Period 1905-1946 - Newspaper accounts for only the months March, April, June, July, August, September, plus one other month for each year were scanned.
Source: United States Department Of Agriculture, Soil Conservation Service, 1977