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Metals in Indoor Horse Arenas

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Metals are naturally occurring in the environment; their concentrations within soils, water, and air are highly dependent on geographic location. Metal concentrations are often impacted by local industries, such as mining or manufacturing. However, some concentration of metals would be found within the soils even if the industry wasn't present. Different types of soils react and store metals differently. For example, clay is a soil type that will bind and sequester metals better than other types of soil. Horse arena footing is often comprised predominately of sand, but sometimes the footing used will contain other soil types, such as clay or loam, and non-soil components, such as fiber or rubber. Every material within the footing has the potential to interact with metals in different ways. Some are better at stockpiling metals while others allow metals to migrate toward the base during watering events. Arena footing may also contain different metals due to geographic location of the arena, origin of the material, and, potentially, the source of the water or any footing treatments. Metals, as elements, are unique compared to compound footing materials because they are neither created nor destroyed, but, instead, are moved around within the environment.

As little research has been completed about metal presence and concentration within horse facility arena footing, a University of Kentucky research collaboration analyzed footing samples for metal concentrations as part of a larger study on indoor arenas. By determining what metals are present within the indoor arena footing, we can begin to develop an idea of the metals which could potentially become airborne particulates as horses are worked in the arenas. To date, metals haven't been as widely considered when considering respirable particulate matter (PM) that can impact horses and humans in the arena environment.

Airborne particulates are grouped into different categories based upon their sizes. It is assumed that all particles are spherical, and the diameter of the sphere is used to describe the size particle. Typical categories include PM 10, PM 2.5, and ultrafine. PM 10 particles have a diameter less than 10 microns, PM 2.5 particles have a diameter less than 2.5 microns, and ultrafine particles have a diameter less than 0.1 microns. For reference, a human hair is approximately 50 to 70 microns in diameter, so PM 10 particles are a fifth the size of a single strand of human hair. A particle is considered able to be respirable or able to travel deep into the lung tissue at PM 2.5 and below. The inhalable particles (PM 10), or particles that reach tissue in the nose, mouth and throat, are also of particles of concern. For example, if particles of lead in the nose or throat were absorbed, they would still be a concern.

The effects of metal exposure have been documented in humans. Susceptibility to metal toxicity is dependent on a number of factors, but life stage is a large determinant. Populations such as children and the elderly are at a higher risk for metal-related issues because of their inability to regulate metal uptake and distribution. In children, this is often due to a higher uptake per pound of bodyweight which causes levels to accumulate to toxic levels faster than they can adequately deal with them. In addition, life events, such as pregnancy or chronic diseases, such as kidney disease, can impact how the body reacts to metal exposures.

Much of the current information about metals exposure in horses is linked to the ingestion of toxic metals from contaminated hay, concentrate feeds, or water with little consideration to soil exposures in working environments. Metal toxicity is an infrequent occurrence and metal poisoning symptoms often take years of exposure to develop. Overall, different metals typically target different organ systems. For example, lead is the most significant environmental metal pollutant, but lead poisoning is rarely seen in horses. When it does occur, symptoms are often peripheral neuropathy, intermittent colic, and mild anemia. Iron poisoning typically results in liver damage, and cadmium toxicity results in kidney and musculoskeletal issues.

In the UK study, the three indoor arena footing groups evaluated were sand, sand and fiber, and rubber. Footings were considered sand when the predominant footing type was sand, and the sand with fiber were footings that were expressly described as being sand and fiber. Finally, the rubber footing consisted of only rubber from an unknown source. There were no sand particles or other materials within the rubber indoor arena footing. All three footings were collected from Central Kentucky indoor arenas. The respirable metals of interest were manganese (Mn), iron (Fe), lead (Pb), antimony (Sb), and cadmium (Cd). Of those metals, Cd and Sb were not detected in any of the samples. Interestingly, levels of Mn, Fe, and Pb varied with the footing type (sand, sand with fiber, or rubber).

Manganese exposure can occur through inhalation or ingestion. Short-term effects of inhalation are irritation to the respiratory tract; longer term exposure potentially results in damage to the lungs and central nervous system. Lead poisoning can also occur from inhalation or ingestion. Symptoms develop from long term exposure and typically include effects on the blood, bone marrow, central nervous system, peripheral nervous system, and kidneys. Iron is interesting because it is crucial for life and is integral in the human body, but excessive iron intake through ingestion can lead to issues within the gastrointestinal tract. There has been some research on iron inhalation, mostly in terms of working within industries that result in exposure to iron oxide fumes, though iron is not usually grouped with the other metals included in heavy metal poison discussions.

As seen in Table 1, manganese was most prevalent in the sand footing arenas, followed by rubber footing arenas, and, lastly, the sand with fiber arenas. Iron concentration in the footing was similarly most prevalent within the sand arenas. However, lead was most prominent in the rubber footing arenas. More arenas with rubber footing would need to be tested to determine if this is a characteristic of rubber footing or due to the small number of arenas surveyed with rubber footing.

Table 1. Metal concentrations within the surface by footing type.

Footing Type	Number*	Metals (ppm) Mn	Fe	Pb
Sand	15	356	12,388	8
Sand w/ Fiber	12	50	1,685	4
Rubber	3	164	6,231	32

*Number of arenas with that type of footing,

The lead levels found within the rubber footing warrant further discussion.

Lead levels within soil are typically 15 to 20 ppm, but according to the Agency for Toxic Substances and Disease Registry (ATSDR), the "EPA's standard for lead in bare soil in play areas is 400 ppm by weight." From the World Health Organization, 400 ppm is an allowable concentration of lead for indoor arena footing. This means that the lead levels found within all footing, including the rubber footing, is within acceptable ranges but for rubber footing is higher than what is normally observed in soil.

Lead levels in the rubber footing could be elevated above normal soil levels for a number of reasons. There were a smaller number of arenas with exclusively rubber footing, which means that any single arena with a higher lead level affects the average lead level calculated. Footing could have higher levels of lead because of the source of the rubber or due to any treatments to the footing including the water used to knock down dust. If the footing is recycled rubber, the original source for that rubber could be high in lead. Overall, it is vital to source quality footing products to ensure that there are no unwanted materials present in the footing.

It should be reiterated that all metal concentrations reported were within normal ranges and do not represent exposure risks to the health of any individuals. A comprehensive list of symptoms and exposure levels can be found in the *National Institute of Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Exposures.* A particular concern with arenas is the potential to inhale dust that is stirred up from the footing during activity within the arenas. The metal exposure limits specifically related to inhalation are defined below. In summary, manganese inhalation levels should not exceed 0.1 mg/m3 in an eight-hour work period. According to the Occupational Safety and Health Administration (OSHA), average iron oxide fume concentration should not exceed 10 mg/m3 in an eight-hour time frame. Finally, lead levels should not exceed 0.05 mg/m3 for inhalation and respiration within an eight-hour work period.

Metals being present in the footing does not automatically mean that metals will be in the air and, therefore, respirable, but it does indicate the amount of respirable metal that may be present. An example calculation for iron in the respirable dust could be evaluated with a couple of assumptions. If the iron levels are 12,000 ppm Fe in the footing, that means that 1.2 percent of the footing is iron. Assuming there is 0.12 mg/m3 of dust in the arena, all of the dust is created exclusively from the footing, and the composition of the dust exactly matches that of the footing, 1.2 percent of the dust would be iron when the dust is produced. That means there would be 0.00144 mg/m3 of iron in the dust. It is unlikely that the composition of the dust would exactly match the footing as different particles (sand, water, metals, etc.) within the footing have varying sizes and weights, however it does provide some idea on the potential concentrations of metal to which participants could be exposed. Larger, heavier particles, like metals, fall out of the air faster than the smaller, lighter particles do.

The age of the arena has the potential to be an important factor when examining the metal composition of the footing. This is because steel structures tend to rust, especially if moisture and condensation are issues within the indoor arena. An increased presence of rust would potentially increase the amount of iron that is deposited onto the arena surfaces and, therefore, in the footing. Within sand arenas, iron was the metal most frequently observed, meaning it has the higher potential to be a respirable particle.

Horseshoes can also contribute to the metal concentrations within arena footing. Iron and manganese are metals of interest because the most common type of steel used for horseshoes is A-36, which has 98 percent iron and 1.03 percent manganese. As horses work in the arena footing, small filings from the horseshoes are deposited into the footing, which could lead to a build-up of iron and manganese that could potentially be airborne. It would take a very long time for them to build up in the footing, but it is still worth noting. Different footing types may cause more filings to be deposited, as sand is more abrasive than a rubber footing.

Most arenas require watering on a regular basis to knock down dust stirred up by the horses as they work. It is possible that with the repeated application of water, metals are deposited into the footing and left behind as the footing dries. This study did not examine how the application of water may affect the concentration of metals within the footing.

A final note is that the indoor arenas where horses and humans are working are safe environments as a whole, but by considering factors like moisture presence, footing quality, and, even metals within the arena footing, these facilities can be made even safer. Chronic exposure to toxins can have just as much of an impact on health as acute, high exposures typically considered dangerous to health. Exposure can be especially problematic to at-risk populations, which include individuals with pre-existing conditions, children, and the elderly. Overall, the purpose of this publication is to bring awareness to possible at-risk populations (horse or human) occupying indoor arenas and to highlight the need to be aware of where the footing comes from and what the footing is treated with. Management of dust, minimizing rust, proper sourcing of footing, and knowing water sources can minimize metal concentrations within the footing. If there are concerns about metal concentrations within footing, samples can be tested.

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References

Bulfin, K., et al., *Occupational Exposures in an Equestrian Centre to Respirable Dust and Respirable Crystalline Silica.* Int J Environ Res Public Health, 2019. 16(17).

Casteel, S.W., *Metal Toxicosis in Horses.* Veterinary Clinics of North America: Equine Practice, 2001. 17(3): p. 517-527.

Framework for Metals Risk Assessment, U.S.E.P. Agency, Editor. 2007.

Iron - Fact Sheet for Health Professionals. 2020; Available from: https://ods.od.nih.gov/factsheets/Iron-Health-Professional/.

Iron Oxide Fume, N.I.f.O.S.a.H. (NIOSH), Editor. 1989: Centers for Disease Control and Preventaion.

Kinuthia, G.K., et al., *Levels of heavy metals in wastewater and soil samples from open drainage channels in Nairobi, Kenya: community health implication.* Scientific Reports, 2020. 10(1): p. 8434.

Lead. 2002, Internationally Peer Reviewed Chemical Safety Information (INCHEM): International Programme on Chemical Safety (IPCS).

Manganese. 2003, Internationally Peer Reviewed Chemical Safety Information (INCHEM): International Programme on Chemical Safety (IPCS).

NIOSH Pocket Guide to Chemical Hazards, D.o.H.a.H. Services, Editor. 2007, U.S. Government Printing Office: Pittsburgh, PA.

Oscar Tarrago, M., MPH and S. Mary Jean Brown, *ASTDR Case Studies in Environmental Medicine: Lead Toxicity*, A.f.T.S.a.D. Registry, Editor. June 12, 2017. p. 185.

Particulate Matter (PM) Basis. Particulate Matter (PM) Pollution 2021; United States Environmental Protection Agency. Available from: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics.

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