Human Health Considerations Associated with Sulfide Ore Mining: A brief overview

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American Medical Association Code of Medical Ethics Chapter 8

Although physicians' primary ethical obligation is to individual patients, they also have a responsibility to protect and promote public health.

AMA Code of Medical Ethics, Chapter 8, available at <u>https://code-medical-</u> ethics.ama-assn.org/chapters/physicians-health-community, accessed 9/20/23.

What we hope to convey today

- Briefly highlight important characteristics of iron ore and sulfide ore mining
- Identify negative human health effects associated with sulfide ore mining
- Introduce how sulfide ore mining may contribute to increased methylmercury
- Review the medical voice of concern raised regarding sulfide ore mining
- Review regulatory tools to evaluate and protect human health: workers and local and downstream communities

Sulfide ore Mining

Desired metals in a mining operation, such as copper, nickel, palladium group metals, can be bound to sulfur in rock. Because of this sulfur bond, they are described as *sulfide minerals*. There are many chemical compounds within this category.

Mining these *sulfide minerals* is referred to as sulfide ore mining.

(millions of tons of rock are excavated to obtain a fractional amount of the desired product)

Jacobs JA, Lehr JH, Testa SM. Acid Mine Drainage, Rock Drainage and Acid Sulfate Soils: Causes, Assessment, Prediction, Prevention and Remediation. Hoboken, NJ: John Wiley & Sons; 2014.

Iron Ore and Sulfide Ore General Characteristics



Iron ore (taconite) mining

- Rock containing iron-bearing minerals (includes iron oxides and iron carbonate) has less sulfur
- General reaction with air/water = rust
- Mining rock & waste less likely to produce acid (although still may increase mercury contamination of fish)

Sulfide ore (copper-nickel) mining

- Ore body contains sulfide minerals
- General reaction with air/water can produce acid, sulfate
- Potential for release of heavy metals in ore

Poveromo JJ. Iron ores. In: Wakelin DH, Fruehan RJ, eds. The Making, Shaping and Treating of Steel. 11th ed. Pittsburgh, PA: The AISE Steel Foundation; 1999:547-642.

Unique risk of Sulfide ore Mining: ACID MINE DRAINAGE



Photo courtesy of the U.S. Geological Survey. 1998. Status and trends of the nation's biological resources. Vol. 1. Reston, VA: U.S. Department of the Interior. Available at: http://www.nwrc.usgs.gov/sandt/.

What experience shows us:

 Abysmal track record of sulfide mining elsewhere coupled with our geography: WATER-WATER-WATER=creation of acid mine drainage and release of toxic metals

Once we option this door, we can never close it

• Examples:

 Kuipers et al (2006) studied 25 operating hard rock mines and their EISs: all predicted compliance with water quality standard within their EISs however pollution from 85% of mines near surface water and 93% of mines near ground water exceeded water quality standards. 89% had inaccurately predicted that they would not create AMD.

 Earthworks article studied fourteen operating copper mines representing 89% of the US copper production. 100% had pipeline spills or accidental releases...

Major toxins associated with sulfide mining also on WHO list:

World Health Organization's Chemicals of Major Public Health Concern:

JWorld Health Organization. Preventing disease through healthy environments: Action is needed on chemicals of major public health concern. Geneva: World Health Organization; 2010. Available at: www. who.int/ipcs/features/10chemicals_en.pdf?ua=1.

- <u>(Particulate) Air pollution*</u>
- Arsenic*
- Asbestos-like fibers*
- Benzene
- Cadmium*
- Dioxin & Dioxin-like substances
- Inadequate or excess Fluoride
- Lead*
- Mercury*
- Highly hazardous pesticides

In addition: Nickel, Manganese, Fluoride, Nitrates

Sulfide mining health considerations: Air Pollution

- <u>Airborne particulates</u> including fugitive dust, silica dust
- <u>Additional air pollution (directly from</u> mining activity as well indirect impacts from electrical power generation with fossil fuel source)
- Inhaled, small particles lead to oxidative stress and inflammation

HEALTH EFFECTS are numerous:

- Increased risk cardiovascular event
- Long term increased risk of hardening of arteries
- Increased risk of blood clots
- Increased tendency toward metabolic imbalances
- Emergiing evidence if increased dementia risk



Image of truck with fugitive dust accessed from https://www.thermofisher.com/blog/mining/is-your-fugitive-dust-control-plan-effective-enough/ on March 7th, 2017.



Sulfide mining health considerations: Asbestos & Elongate Mineral Fibers (EMF)

- Asbestos and asbestiform fibers
- HEALTH EFFECTS of asbestos include lung disease and mesothelioma
 HEALTH EFFECTS OF EMFs are being studied, complex



Sulfide mining health considerations: Heavy metals

Arsenic Cardiovascular, skin, carcinogen

 Lead Nervous system, blood, cardiovascular, kidneys, probable carcinogen

 Mercury Nervous system, kidney, possible carcinogen

Cadmium Respiratory, kidney, carcinogen (lung)

Sulfide mining health considerations: Nickel

NICKEL

Respiratory, skin (allergy), carcinogenic soluble Ni compounds, possibly carcinogenic metallic Ni (lung)

Sulfide mining health considerations: Manganese

MANGANESE

- Small amounts required
- Larger amounts toxic
- Water limit < 400 mcg/Liter

- HEALTH EFFECTS include:

- Toxic exposures lead to 'Manganism'
- Neurotoxin (Parkinson-like symptoms)
- Toxic to heart
- Toxic to liver
- Increased infant mortality
- Cognitive impairment

Sulfide mining health considerations: Unanticipated failures

- unanticipated interruption of water treatment
- extreme weather event that overwhelms operation
- catastrophic event such as tailing dam breach
- Contamination and destruction of food sources, livelihoods
- death



Sulfide mining health considerations: Sulfate release

- Anthropogenic pollution of freshwater systems is an ongoing global issue
- Aquatic flora and fauna can be severely impaired by sulfate pollution
- Minnesota's native wild rice stands are negatively impacted by sulfate and sulfide exposures



Sulfate in Freshwater Ecosystems

Manoomin, Psíŋ

Seed of an aquatic grass
Indigenous peoples have harvested for millennia
Culturally very important
Shelf stable, gluten free, offers food security
Very favorable nutritional profile





Significant cultural considerations of wild rice:

Data support the connection between participation in traditional practices and improved health (Sasakamoose et al 2017)

In addition to manoomin's cultural and spiritual importance, it is a nutritionally advantageous grain, with a favorable cardioprotective profile offering omega-3 fats, B vitamins, and desirable levels of protein, fiber, carbohydrate, and total fat (Tim and Slavin 2014)

Aqueous sulfates released into the ecosystem from anthropogenic sources like SOCN mining are converted to sulfides which are toxic to wild rice growth. Wild rice does not grow in waters with high levels of sulfate (Myrbo et al. 2017).

Fond du Lac Band of Lake Superior Chippewa: Health Impact Assessment concluded that the persistent health disparities for tribal communities in Minnesota are directly related to the involuntary loss of traditional lands, subsequent disruption of traditional lifeways and the loss of traditional, health-sustaining foods such as manoomin.

Let's talk about sulfates and methylmercury:

Release of sulfate into the environment from anthropogenic source (example: acid mine drainage)

Sulfate reaches wetlands where it can stimulate certain "sulfate-breathing" microorganisms that are capable of converting inorganic mercury to methyl mercury

Enhanced rates of mercury methylation can occur

Methyl mercury bio-accumulates in aquatic ecosystems, including fish species

Humans consume mercury-contaminated fish

Methylmercury Bioaccumulation and Biomagnification:



How these toxins can impact human health



The causes of neurodevelopmental disorders, including ADD, learning disorders, autism spectrum disorder, language disorders and intellectual disabilities are complex and multifactorial, but the connection to exposures to heavy metals, particularly methylmercury, is known.

Bennett D, Bellinger DC, Birnbaum LS, et al. Project TENDR: Targeting environmental neurodevelopmental risks the TENDR consensus statement. Environ Health Perspect. 2016;124(7):A118-22. Photo by Scott Housely, 2015 courtesy of the Center for Disease Control, content provided byJulia Whitney, Stephen Griffin

Those most vulnerable:





- Developing fetus (pregnant women)
- Infants and children (lactating mothers)
- People dependent on local fish as quality food source and/or cultural practice

Why is methylmercury so toxic for the developing nervous system?

- Placenta is unable to filter out heavy metals
- Methylmercury and other heavy metals are then able to cross the blood-brain barrier in infants and children up to age 2-3 years of age
- Once heavy metals reach nerve or brain tissue the amount of damage is proportional to the rate of growth and cell division of the tissues (brain size doubles in the first year of life and by age 3 is approx. 80% adult volume)
- Lasting negative effects when fetuses are exposed to concentrations at levels that are only 10%-20% of toxic levels for adults

Minnesota Department of Health study

Published 2011

- Heel cord blood from newborn babies in Western Lake Superior Basin (MN, WI, and MI)
- Significant elevations in mercury found in 10% of newborns
- Methylmercury exposure is already a public health issue in northeastern Minnesota

Mercury Levels in Blood from Newborns in the Lake Superior Basin GLNPO ID 2007-942 Final Report November 30, 2011 Submitted by: Patricia McCann Minnesota Department of Health Division of Environmental Health

Lasting Effects of Neuro-developmental and other health impairments

Individual costs
Community costs
Healthcare costs

Medical Voice of concern raised:

- Many medical and public health organizations
- Multiple letters from health providers and non-profits supporting human health
- Resolutions by MAFP/AAFP and petition to Minnesota's Environmental Quality Board (EQB)
- Articles in medical literature

 Consistent ask for comprehensive Health Risk Assessment and Health Impact Assessments as part of EIS or EAW for sulfide-ore copper nickel mining projects

These were not done...

Published Articles:

Clinical 400 Health Affairs

Sulfide Mining and Human Health in Minnesota

BY EMILY ONELLO, MD, DEB ALLERT, MD, STEVE BAUER, MD, JOHN IPSEN, MD, PHD, MARGARET SARACINO, MD, KRIS WEGERSON, MD, DOUGLAS WENDLAND, MD, MPH, AND JENNIFER PEARSON, MD

Sulfide mining (specifically copper-nickel sulfide mining) represents a significant departure from Minnesota's iron mining tradition. Sulfide mining can produce acid waste and sulfates that mobilize the release of heavy metals into the environment. These metals include known neurotoxins such as lead and mercury. Mining activities also create airborne fibers and pollutants that can contribute to increased morbidity. The short- and long-term effects of exposure to these substances on human health should be considered in present and future sulfide mining proposals. In addition, Minnesota physicians need to understand the potential adverse mental and physical health effects of sulfide mining on mine workers and residents of communities near mining operations

water (H₂O)

he Duluth Complex is a geological FIGURE 1 formation that contains deposits of copper, nickel and palladium group metals. It is located at the eastern end of the Mesabi Iron Range in northeastern

Minnesota.' PolyMet Mining plans to build an open-pit mine in the northeastern part of the state to recover those valuable metals. Other mining companies are also exploring mineral deposits and preparing proposals for extracting them. During the past three years, multiple organizations representing health care professionals have voiced concern about the

potential effects of copper-nickel mining on human health. The Minnesota Medical Association, Minnesota Public Health Association, Minnesota Nurses Association and Minnesota Academy of Family Physicians have each endorsed deeper inquiry

Metal sulfide oxidation mining, and specifically of copper-nickel mining. Although the majority of debates sequence using pyrite as an example about sulfide mining in our state have been framed as "environment serves jobs" the impact on human health needs to be a Pyrite (FeS2) is exposed to air (O2) and part of these discussions. Sulfide mining has significant potential for the release of toxic chemicals into the environment. These include a number A sequence of reactions occur creating sulfate, ferric hydroxide and hydrogen ione of chemicals identified by the World Health Organization as being of major public health concern: arsenic, asbestos cadmium, lead and mercury.3 Given this ominous list, and the possible synergistic involving putite iron sulfate and water esulting in the release of sulfuric acid. effects of co-exposure to more than one of these chemicals, it is important that physicians understand why concerns are being Sulfuric acid promotes release of other

e: lacobs JA, Lehr JH, Testa SM. Acid I age, Rock Drainage and Acid II. Drainage and Acid Sulfate Solis: nent, Prediction, Prevention and sboken, NJ: John Wiley & Sons; 2014

metals from rock and causes harm to

aquatic ecosystems.

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raised about this type of mining.

into the potential health effects of sulfide



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Risks and costs to human health of sulfide-ore mining near the Boundary Waters Canoe Area Wilderness

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ABSTRACT

Sulfide-ore copper nickel (SOCN) mining is being considered in water-rich Minnesota. Given pollution resulting from SOCN mining elsewhere, careful scrutiny is necessary examining the risks associ-ated. Health considerations of mining within the Rainy River Watershed, the geographic region at the headwaters of the Boundary Waters Canoe Area Wilderness (BWCAW), Ontario's Quetico Park (Quetico), and Voyageurs National Park (VNP) are examined. This discussion considers toxins released from SOCN mining, examines data regarding degradation of water quality and deleterious environmental impact from SOCN mining elsewhere, considers the most vulnerable populations, and recognizes the broader effects to public health as well as benefits of existing wilderness. Recent federal decisions to reinstate mineral leases and abort the environmental assessment process have placed this unique and irreplaceable region of our country at substantial risk. The overall health and well-ness of this region will very likely be negatively affected by SOCN mining, and economic costs will predictably outweigh benefits. In addition, negative impacts on water, fish and wild rice will likely degrade nutritional and tribal resources resulting in violation of usu-fructuary rights of tribal communities.

Introduction

Minnesota is known as "the land of 10,000 lakes." The name comes from the native Ojibway (or Anishinaabe) language and translates to "land of sky-blue waters." The state lies at the head of three continental watersheds and shares its northeastern border with Lake Superior, which is estimated to contain 10 percent of the planet's freshwater (Minnesota Water Facts 2010). What Saudi Arabia is to oil, Minnesota is to freshwater. The Duluth Complex is a mineral deposit containing copper, nickel, and precious metals that lies within the Lake Superior and Hudson Bay Watersheds (NorthMet Mining Project and Land Exchange 2015). Active SOCN (also referred to as hard rock) mining is now being pursued in northern Minnesota, an area without any prior SOCN mining,

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Sulfide-ore mining AND human health in Minnesota WHERE ARE WE NOW?

BY JENNIFER PEARSON, MD; DEB ALLERT, MD; JOHN IPSEN, MD, PHD; MARGARET SARACINO, MD; STEVE SUTHERLAND, MD; KRIS WEGERSON, MD: AND EMILY ONELLO, MD

or many years. Minnesotans have been reading headlines regarding the prospecting, permitting and potential for sulfide-ore copper nickel (sulfide-ore) hardrock mining in Minnesota. Although the debate is not a new one, the landscape surrounding decisions regarding this type of mining within Minnesota's borders is dynamic and constantly changing As 2021 was ushered in, so were new legislative and legal efforts affecting sulfide-ore mining. Amid state and federal legislation and lawsuits, healthcare providers in Minnesota have continued to stay abreast and weigh in on the potential human health effects of these decisions. Given the shifting landscape, it is timely to understand where we are right now and why concerns for human health remain at the forefront of this issue

Background

The Duluth Complex, a geological formation in northeastern Minnesota, contains metals that are sought for many modernday uses, including copper, nickel and platinum group metals. These metals are naturally bound to sulfides in the ore body and millions of tons of rock are excavated to obtain a fractional amount of the desired product. At both the mine site and in tailings and waste rock piles, exposure of this excavated ore to air and water triggers a chemical reaction that causes the sulfides to oxidize; this reaction creating sulfurio



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ELIMATE CHANGE AN HEALTH



Regulatory Tools to evaluate health risks: HRA and HIA



HRA

- Focuses on the Social Determinants of Health
- Primarily qualitative
- Stakeholder engagement highly valued

- Focuses on specific contaminants/ hazards
- Primarily quantitative (deriving specific values)
 - Expert-driven

* Note: Both have systematic processes & are based on science.

HIA & HRA • What is a Health Impact Assessment?

Why HIA?

- Identify harms and benefits before decisions are made
- Identify evidence-based strategies and recommendations to promote health and prevent disease
- Support inclusive and democratic decision-making and increase transparency in the decision-making process
- Support community engagement in the decision-making process and foster community empowerment
- Advance equity and justice

* Note: There are many ways to insert health into decision-making. HIA is one way.

Physician Advocacy for Health Impact Assessments



October 2016 MAFP members and leadership advocate for MAFP's request for a MN Rule change to require Health Risk and Health Impact Assessments as part of the Environmental Review process. Pictured, left to right: John Ipsen MD, Jennifer Pearson MD, Maria Huntley MAFP Executive Director, Dania Kamp MD MAFP 2016 President, Emily Onello MD, Deborah Allert MD, and Kristan Wegerson MD.

Review: Core Concerns Regarding Sulfide ore Copper Nickel Mining

- At least 6 of the 10 toxins of major public health concern listed by the World Health Organization (mercury, lead, arsenic, asbestos, particulate air pollution, cadmium) are released from sulfide-ore mining
- This type of mining also releases sulfates, which increase the amount of methylmercury in the environment
- Abysmal track record of sulfide mining elsewhere coupled with our geography- WATER-WATER-WATER= creation of acid mine drainage and release of toxic metals
- Once we option this door, we can never close it

And again... A few key points regarding potential toxicity:

- Heavy Metals with many harmful affects to human health: cancer, heart and lung disease, neurodevelopmental disorders
- Methylmercury is a chemical with significant toxicity to humans
- Methylmercury exposure can occur by eating fish and other food sources contaminated via bioaccumulation and biomagnification within in the food chain
- Developing human brains are more susceptible to damage at much lower concentrations of methylmercury
- MDH study demonstrated mercury as already existing problem
- Neurotoxic damage from methylmercury can have significant impacts on individuals and society
- Health impacts of mercury exposure could be disproportionate, affecting people consuming local fish at higher rates- a justice issue

What can you do...?

Educate yourself/others about this topic

- Continue to pressure law makers and regulatory agencies to mandate that human health be rigorously considered/studied before permitting toxic industries such as sulfide-ore copper nickel mining
- Support key local organizations fighting for our clean water
 - Tamarack Water Alliance
 - Water Legacy
 - Minnesota Center for Enviornmental Advocacy (MCEA)
 - Honor the Earth

ADDITIONAL READING:

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THANK YOU FOR BEING HERE!!