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Impact of China's Nonferrous Metals on the Health of Surrounding Residents

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ABSTRACT

China is now the world's largest producer of refined metals due to the rapid growth of its non-ferrous metals sector, which produces important metals like copper, zinc, and lead. This growth has boosted the economy but raised serious pollution concerns, especially health risks to nearby residents from mining and smelting. This article focuses on health risks near smelting plants, particularly from sulfur dioxide and heavy metal emissions causing long-term and respiratory diseases. Through case studies and new research, it finds that residents near factories face long-term and cumulative health issues, especially in areas with poor pollution control.

KEYWORDS

Non-ferrous metals; Health; Pollution

1 Introduction

China is the world's largest producer and consumer of non-ferrous metals, including aluminium, copper, and lead. Over the past decade, production has grown continuously, making it a leader globally and a significant part of the national economy. Growth accelerated after joining the WTO in 2001, with production and consumption volumes among the highest. Since the 21st century, industrial value added to GDP rose from 0.66% in 2001 to 2.05% at an annual 16% rate (National Bureau of Statistics of China). This drove economic development, aiding urbanisation and infrastructure. However, rapid growth brought severe environmental issues: mining and processing generate large amounts of waste and pollutants harming human health and ecosystems. Despite stricter regulations, balancing economic efficiency and environmental health remains challenging.

2 Environmental pollution and spatial dynamics

2.1 Main pollutants

Statistics show lead poisoning accounts for 0.06% of the global disease burden, causing over 80,000 deaths in 2013 (Zhai et al., 2023). China has prioritised environmental protection, strengthening management of non-ferrous metals industry pollution. While total emissions are controlled, issues persist in some regions and for certain pollutants. Non-ferrous metal processing is a major source of heavy metal pollution (Jiang et al., 2021); lead (Pb), copper (Cu), and zinc (Zn) emissions have led to significant soil accumulation. A southwestern China lead and zinc smelter, with combined cadmium (Cd) and lead (Pb) pollution, is a typical example causing severe ecological and health risks (Zhang et al., 2012). Understanding heavy metal pollution characteristics and risks is crucial for prevention, remediation, and restoration.

2.2 Pollution transport mechanisms

There are two main sources of heavy metal pollution in non-ferrous metals processing soils. First, cadmium (Cd), lead (Pb), and zinc (Zn) particles in smelting smoke are carried by wind and deposited atmospherically. Pollution concentration decreases with distance from the factory, as seen in soils near copper smelters where Cd and Pb concentrations drop with distance, indicating fly ash deposition is the primary cause (Adnan et al., 2022). Second, smelter pollution can contaminate downstream soils via groundwater and surface runoff (Ritter et al., 2002), showing untreated wastewater emissions pose significant risks. Smelters near cities, combined with urban industrial growth, endanger farmland and green spaces. China's rapid urbanization creates a unique risk with close proximity of living areas and industrial sources, differing from long-standing pollution zones in the US and Europe.

Early intervention improves pollution control. National financial assistance and policy recommendations are key for soil cleanup. Chinese provincial studies show regions implementing the "Soil Pollution Prevention and Control Action Plan" early and responding swiftly had better outcomes (Li et al., 2019). Soil pollution policies must consider pollution type, prevention, risk evaluation, cleanup, and funding. Strengthening environmental regulations is crucial to reduce soil pollution near metal smelters.

2.3 The process of urbanization in China

China has a distinctive spatial configuration of smelting plants during urbanization (Li et al., 2022), unlike developed countries where smelters are in remote areas, separating industry and residences to reduce exposure. China's rapid urbanization and uneven land planning have placed many non-ferrous metal smelters on city outskirts or urban-rural areas. This 'industrial-residential' high-density overlay means residents are daily exposed to heavy metals and harmful gases. Proximity exacerbates air, water, and soil pollution, making cleanup and risk avoidance harder. This coexistence with pollution sources is a unique public health challenge.

3 Impact on the local community's health

3.1 How local residents are exposed to toxic substances

China's non-ferrous metals industry, the world's largest refined metals producer and an economic pillar, has obvious environmental costs. Production releases heavy metals (lead, cadmium, arsenic, mercury) and pollutants like sulphur dioxide, which enter the body via inhalation, atmospheric deposition, drinking water contamination, and soil accumulation through the food chain. This composite exposure threatens mining and smelting area residents.

Epidemiological studies link long-term low-level exposure to chronic health issues. Lead elevates children's blood lead levels (Lanphear et al., 1998), impacting neurological development, causing cognitive impairment, attention deficit, hyperactivity, and poor academic performance. Cadmium exposure is linked to adult chronic kidney damage, osteoporosis, and cancer risk (Ma et al., 2022). Arsenic, common in mining areas, increases skin, bladder, and lung cancer rates (Boffetta, 2004). Children, the elderly, and low-income groups are more vulnerable due to sensitivity or lack of protection. In severely polluted areas like the Xiangjiang River basin with long-term heavy metal excess, tailings dam leakage, red mud storage dust, and poor environmental regulation of small and medium enterprises, health risks remain high in key metallurgical areas (Hunan, Yunnan, Henan). A comprehensive intervention mechanism covering source clean production, process control, end-of-pipe governance, remediation, and health monitoring is needed for coordinated industrial and public health development.

3.2 Case study: impact of the zhuzhou lead smelter on children's health

Zhuzhou, a central China non-ferrous metals production base, has long seen lead smelting impact the environment and health. He et al. (2009) found children within 2 km of a major lead smelter had an average blood lead level (BLL) of 9.6 μg/dL, above the US CDC's 5 μg/dL reference, indicating risk. About 30% of surveyed children showed lead poisoning signs: learning difficulties, slow reaction, inattention, aggression, and mood swings, similar to lead's effects on the central nervous system, linking exposure to long-term neurological and cognitive damage. Affected children often come from low-income families with poor living conditions, and parents' lack of awareness strengthens the exposure-health harm link.

This case highlights public health dangers of non-ferrous metal smelters in densely populated areas, especially with weak environmental laws and poor resident protection. Polluted air and water harm children's health, emphasizing the need for better emission control, environmental monitoring, and public health measures like child screening and risk education for high-risk families.

3.3 Social and economic vulnerability and environmental injustice

Environmental pollution health risks are socially and economically stratified. Low-income families near polluting metal smelters can't move, facing higher health risks. Industrial areas have more migrant workers and rural residents, often in low-cost, poor environmental housing. They lack good healthcare and environmental health information, hindering diagnosis, treatment, and protection advice. This widens the gap between exposure and health outcomes.

This is environmental injustice, putting marginalized communities at a systemic disadvantage. They lack resources, protection, and influence over pollution sources, posing challenges for social justice, environmental governance, and public health. An environmental justice approach in pollution rules is needed to identify high-risk groups, prioritize actions, and promote fair planning, resource distribution, and risk communication for sustainability.

4 Policy response and governance measures

4.1 Regulatory measures

The Chinese government has enacted national laws and policies for non-ferrous metals pollution control and environmental restoration, including the "Soil Pollution Prevention and Control Action Plan" (2016), national industrial emission standards (GB), and industrial park planning.

The Action Plan emphasizes risk assessment, graded governance, and source control, introducing a 'polluted land registry' for key polluters. Emission standards set limits for air, water, and heavy metals, aiding enforcement. Industrial park planning encourages concentrating non-ferrous enterprises in parks with pollution treatment capacity, improving control efficiency and reducing regional cumulative pollution (Food and Agriculture Organization).

Policies have had initial success: the Ministry of Ecology and Environment (2022) reports 40% reduction in non-ferrous metals industry sulphur dioxide emissions (2015-2020), improving air and surface water in key areas. However, regional implementation varies, especially with many small and medium enterprises and weak regulation, facing enforcement challenges. Illegal small-scale smelters operate outside regulations with poor. Local governments sometimes prioritize costs over environment, leading to a gap between 'paper compliance' and 'actual implementation'. Strengthening policy execution requires enhancing local enforcement, establishing third-party monitoring and public participation, improving environmental credit systems, and including environmental targets in local officials' performance evaluations.

4.2 Governance technology and funding restrictions

China has a comprehensive environmental governance policy framework, but technical and funding issues hinder pollution control, especially for non-ferrous metal processing remediation. Complex pollutants and diverse media require advanced technology and continuous funding, pressuring local governments and small and medium enterprises.

Technically, existing pollution control and soil remediation technologies aren't widely applicable to mining area complexities. Physical isolation, chemical stabilisation, and phytoremediation have pilot success but have limitations (long cycles, poor adaptability, limited metal activity control). Highly polluted areas need multiple technologies, but composite pollution remediation integration, equipment intelligence, and monitoring automation need improvement.Heavy metals' non-degradability makes remediation a long-term, high-technical task requiring continuous operation and maintenance.

Financially, pollution control investment needs exceed local government capacity. Soil and water remediation costs millions to billions, beyond most small and medium metallurgy enterprises. Economic downturns lead local governments to prioritize 'hard' infrastructure over long-term environmental projects. National funds (Central Soil Pollution Prevention Fund, Ecological Protection and Restoration Fund) face implementation obstacles. Unclear pollution responsibility, with bankrupt or refocused historical polluters, hinders investment and financing, slowing remediation and eroding public trust.

Overcoming these requires a collaborative, multi-level mechanism: accelerating domestic pollution control technology development; establishing diversified financing based on 'polluter pays'; promoting green financial tools (environmental liability insurance, green bonds) for sustainable support.

4.3 Recommendations for comprehensive management

Multi-source, multi-media pollution from China's non-ferrous metal industry needs collaborative governance to reduce mining area health risks, covering source control, process monitoring, and pipe repair.

First, encourage green industry development to reduce source pollution (Lin & Chen, 2020). The government should tighten environmental permits, restrict energy-intensive, polluting projects, promote clean production, recycling, and green technology to cut pollution. Offer tax breaks and funding for pollution control equipment to ease business green transition costs.

Second, expand and strengthen process supervision. Establish a multi-stakeholder governance system with online pollution source tracking in key areas, combining government oversight, public supervision, and third-party assessments. Small and medium enterprises should use "regional concentrated governance + joint enforcement," building industrial park wastewater and gas treatment facilities for cost sharing and economies of scale. Include environmental enforcement results in business credit systems to increase violation costs and raise environmental awareness.

Third, establish a "restoration + health intervention" mechanism to protect public health and the environment. Develop soil and water restoration plans for polluted areas, prioritizing residential and agricultural areas. Focus on vulnerable groups (elderly, pregnant women, children), establish exposure monitoring and disease alert mechanisms through routine health checks, drinking water testing, and blood lead screening to help residents manage risks. Address environmental management social inequality by prioritizing vulnerable groups' environmental health rights in pollution control and resource allocation via environmental justice. Increase public participation and information sharing in policy making and project evaluation to ensure marginalized voices are heard.

Finally, adopt a long-term perspective, supporting institutional innovation and fiscal reform. Create national inter-departmental collaboration for integrated policies (natural resources, environment, health, finance). Develop new environmental investment and financing methods to attract social capital, using green bonds, environmental funds, and pollution liability insurance for long-term restoration project funding.

In short, non-ferrous metals industry pollution cleanup is complex, involving health, environment, economy, and society. Combining policy, technology, funding, and social support is needed to establish long-term remediation, protect public health, and achieve economic-environmental harmony.

5 Conclusion

This article analyses the impact of China's rapidly expanding non-ferrous metal industry on local residents' health, focusing on pollution emissions, health risks, cases, and socio-economic factors, and discusses current governance effectiveness and limitations. As the world's largest non-ferrous metals producer, China faces severe environmental and health challenges. Smelting heavy metal and gas emissions cause complex exposure via air, water, and soil, risking children, the elderly, and low-income groups.

The Zhuzhou lead smelter study shows pollution has concentrated, regional, cumulative intergenerational health impacts. Epidemiological data reveals abnormal blood lead levels, neurodevelopmental disorders, and chronic diseases. Smelter urban-rural layout, disadvantaged group concentration, and lack of primary healthcare exacerbate environmental health inequalities, exposing industrial development-social equity contradictions. China has made progress with the 'Soil Pollution Prevention and Control Action Plan', emissions standards reform, and industrial park planning, but pollution control faces technical, funding, regulatory fragmentation, and policy implementation challenges, especially in areas with many small and medium enterprises and poor enforcement, leading to persistent 'pollution hotspots'.

The article emphasizes a systematic, multi-level governance system, recommending source control, process regulation, end repair, strengthened public health protection, and environmental justice promotion. Policy efforts should develop green financial tools, environmental responsibility systems, and public participation mechanisms for resource allocation, responsibility identification, and social fairness. Further research on pollution-health quantitative relationships can improve modelling and risk prediction. Exploring cross-departmental governance, pollution compensation, and smelting zone industrial transformation provides theoretical and policy support for sustainable industry development and resident health.

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