SAFER PHOSPHATES FOUNDATION

BEYOND THE SURFACE

ANALYSIS AND POLICY RECOMMENDATIONS FOR SOIL PROTECTION

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Foreword

Safer Phosphates™ is a Dutch foundation established in 2023 as a result of a growing social and political concern over soil protection, with the aim of contributing to EU policy and regulatory debates around the use of phosphates and their environmental impacts, in particular with regard to soil health.

Safer Phosphates is committed to increasing awareness of the presence of contaminants in fertilizing products and, consequently, in our food, and it aims to make products with as little contamination as possible available both in Europe and around the world. The ultimate objective of Safer Phosphates is to promote sustainable agriculture and better food in Europe through informed decision-making and science-based policy options in the European market for fertilizers with low levels of contaminants.

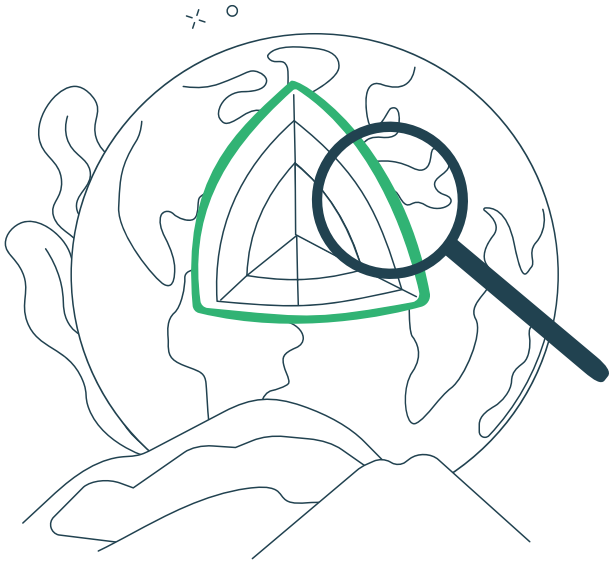
The foundation aims to address the issues of food security, food safety, human health, precision agriculture and sustainable chemistry with a particular focus on safer phosphates, and also to promote the use of scientifically assessed safer phosphates around the world.

This is the Safer Phosphates Foundation's first publication to present an overview of the European policies aimed at preventing, monitoring and managing heavy metal pollution in soils. We highlight the case of cadmium (Cd) contamination because its accumulation in soils and living organisms causes severe and permanent damage, as it is a carcinogen and considered the third most hazardous environmental pollutant. Furthermore, the EU has already provided rules on Cd thresholds in fertilizers, and it is possible that these thresholds may become more ambitious in the near future. We also summarize current scientific knowledge to substantiate our call for urgent action. Finally, we conclude with a list of priority issues to be addressed by society and the European Union (EU) to safeguard soils.

Safer Phosphates aims to foster debate on all aspects of soil pollution by heavy metals, with a special focus on the role of fertilizers.

Further information is available on our website, through our social media accounts (LinkedIn, X and YouTube) and via our monthly newsletter.

Beyond the surface



The health of European soils is increasingly recognized as a critical issue with far-reaching implications for agriculture, the environment and human well-being. Over the years, intensive agricultural practices, urbanization and industrial activities have led to soil degradation and loss of fertility. Contamination by heavy metals is among the key challenges facing European soils, undermining the sustainability of agriculture on the continent and presenting a serious threat to human health. For instance, fertilizers are one of the many factors contributing to the contamination of soils and, consequently, of food as well. At the same time, modern agriculture demands more efficient and sustainable tools to treat and protect the environment: that is why the choice of safer fertilizers is so important.

Fertilizers are made up of a combination of nutrients that facilitate plant growth and soil fertility. In order to meet the needs of a growing population, fertilizers are seen as the key to food safety and food security. For this reason, it is essential to focus on how they are manufactured and used: fertilizers contaminated with excess impurities, such as heavy metals, could pose environmental and health risks. On the contrary, phosphates with lower levels of heavy metals provide the prospect of food safety and food security as well as a more sustainable future for agriculture.

Since the mid-1970s, several processes have been developed to remove Cd from phosphate rock and phosphoric acid, and therefore from phosphate fertilizers. As the removal of Cd represents an extra cost, producers prefer to avoid it. The cost is not insurmountable, however, and Cd removal is essential to making soils healthier and agriculture more sustainable. Cd removal technology is constantly advancing, and there exist alternatives to contaminated fertilizers. As such, proper regulation and awareness are needed to ensure sustainable agriculture in the future.

Background

With the adoption of the European **Green Deal** in 2019, the EU initiated a comprehensive set of policies aimed at protecting the environment from degradation and fostering sustainability across various sectors. These policies, encompassed in the Green Deal, have elevated environmental concerns to the forefront of decision-making, with specific emphasis on agricultural practices and fertilizer usage.

One of the pillars of the Green Deal is the EU's commitment to achieving zero pollution by 2050, including stringent targets for improving water and soil quality. Agricultural policies, notably the Farm to Fork Strategy, aim to reduce nutrient losses and minimize the use of chemical pesticides and fertilizers, including those containing heavy metals such as Cd.

In addition to fertilizer regulation, the EU has implemented a series of legislative measures aimed at preventing, monitoring and managing heavy metal pollution in soils. These include directives such as the Water Framework Directive, the Soil Framework Directive and the Industrial Emissions Directive, which establish standards, guidelines and compliance mechanisms to safeguard soil quality and protect ecosystems and human health.

Numerous scientific studies have provided insights into the factors influencing the accumulation and distribution of heavy metals in soil, highlighting the importance of continued research and monitoring efforts. Despite advancements in understanding soil contamination, there remain significant gaps in knowledge, particularly regarding the long-term impacts of heavy metal pollution and the effectiveness of mitigation strategies. For this reason, scientific research in this field is highly needed in order to reduce the accumulation of heavy metals in soils and attenuate their impact on the environment as well as on human and animal health.

One of the pillars of the Green Deal is the EU's commitment to achieving zero pollution by 2050.

In the EU's 2024–2029 mandate, research and innovation will play an important role among the main items on the EU agenda. The agenda will focus on research, and funds will be provided for technical and business development as well as implementation of the provisions of the EU Green Deal. In this context, it will be essential to invest in research and development aimed at combating environmental pollution and improving human health, incentivizing production of fertilizers with low levels of contaminants in particular.

ACT NOW!

Current EU legislation – more precisely, Regulation 2019/1009 on fertilizing products – sets limits of 60 mg/kg P2O5 for Cd in fertilizers and promotes the production and use of low-cadmium fertilizers. However, these limits are still inadequate when it comes to reducing the speed of soil contamination. An upcoming review of thresholds is expected to propose a further reduction in cadmium content in fertilizers from the current 60 mg/kg P2O5.

The Safer Phosphates Foundation calls for decisive action on the part of policymakers to address heavy metal contamination in European soils. Introducing strict limits on cadmium must be the first practical step. A range of 10–20 mg/kg as a ceiling is both feasible and necessary to stop pollution and prevent further harm.

Other key recommendations include implementing harmonized thresholds for heavy metals in fertilizers, promoting improved farming practices, fostering collaborative efforts between sectors, revising regulatory frameworks, setting tolerance thresholds for heavy metals, and investing in research and development initiatives.

By adopting these recommendations, policymakers can mitigate the adverse impacts of heavy metal contamination, promote sustainable agricultural practices, and ensure a greener and healthier future for Europe.

Strict limits on cadmium:
10–20 mg/kg

EU policies

The Green Deal

The Green Deal is more than one piece of legislation or legislative package. Since 2019, all environmental, agricultural and industrial policy in the EU has been heavily influenced by the Green Deal, which has become the flagship achievement and ambition of the Ursula von der Leyen–led Commission.

The Green Deal is a complex, comprehensive set of policies that are constantly under review and reconsideration, as the political, economic and geostrategic context in Europe and its neighbourhood changes. This ambitious plan encompasses a wide array of policies and measures addressing various sectors, from energy and transport to agriculture and biodiversity. At its core, the European Green Deal seeks to decouple economic growth from resource use and environmental degradation while fostering innovation and creating green jobs.

Due to their environmental impact, agricultural and agriculture-related policies are among the main targets of the Green Deal, and significant changes have been introduced over the past five years. These changes have been encompassed in the Farm to Fork Strategy.

One of the pillars of the Green Deal is the EU's zero-pollution vision by 2050, which encompasses air, water and soil pollution. Key targets were set for 2030, including on the improvement of water quality and waste reduction, the improvement of soil quality through a 50% reduction in nutrient losses and the use of chemical pesticides – a target that has since been jeopardized by the failure to adopt relevant legislation. On fertilizers, the Green Deal and the Farm to Fork Strategy established a paradigm focused on the containment of nutrient losses, which, if halved by 2030, would reduce fertilizer use by 20%.

One of the issues that the Green Deal should be concerned with is countering the pollution and contamination of European soils with heavy metals, such as Cd. Legislation on contaminants in food, water and soils has been either introduced or placed under review in recent years, with stricter thresholds and measures proposed as a consequence.

EU legislation against heavy metal pollution

Heavy metal pollution in soil poses significant environmental and health risks, with implications for ecosystems, agriculture and human well-being. Since the early 2000s, the EU has recognized the issue and implemented a series of legislative measures aimed at preventing, monitoring and managing heavy metal pollution in soil.

In addition to setting standards and guidelines, the EU has established robust compliance and enforcement mechanisms to ensure the effectiveness of these measures. There are many pieces of EU legislation aimed at preventing, monitoring and managing heavy metal pollution in order to safeguard the environment and human health; the most important examples are listed below.

EU SOIL STRATEGY FOR 2030

The EU Soil Strategy for 2030 was launched by the European Commission in 2021, establishing a framework and specific measures to safeguard and restore soils, promoting sustainable use. It outlines a vision and objectives aimed at achieving healthy soils by 2050, with tangible actions planned by 2030.

SOIL MONITORING AND RESILIENCE DIRECTIVE

The Proposal for a Directive on Soil Monitoring and Resilience, adopted by the Commission in July 2023, aims to ensure the sustainable use and restoration of soils within the EU, with the goal of achieving healthy soils by 2050. The proposal establishes a harmonized definition of soil health, a comprehensive monitoring framework, and measures to

identify and remediate contaminated sites. The European Parliament is keen to emphasize the importance of achieving soil health by 2050 and to support the harmonized definition of soil health and comprehensive monitoring. Their recommendations include flexibility for Member States when it comes to monitoring design as long as they adhere to the Commission's proposed approach, as well as the creation of a public list of contaminated sites, applying the polluter-pays principle and the development of a toolbox for sustainable soil management. Meanwhile, the European Council discussed the need to incorporate national monitoring systems into a single monitoring system in order to address differences in soil quality and monitoring systems among Member States. The legislation is expected to be adopted by the end of 2024.

WATER FRAMEWORK DIRECTIVE

One of the first pieces of legislation adopted on preventing heavy metal pollution of the environment is the Water Framework Directive (2000/60/EC), which is currently being partially revised. While primarily focusing on water quality, this directive protects soil indirectly by addressing pollution sources that can affect both water bodies and soil. It sets environmental quality standards for water, including limits on heavy metal concentrations, thus reducing the risk of soil contamination through water pollution.

INDUSTRIAL EMISSIONS DIRECTIVE

The Industrial Emissions Directive (2010/75/EU) regulates industrial activities with significant pollution potential, including emissions of heavy metals. It establishes emission limits and best available techniques for industrial installations, aiming to prevent or minimize heavy metal pollution in soil resulting from industrial activities.

MONITORING HEAVY METALS

Concerning the measures that the EU has established for monitoring heavy metals, the European Soil Monitoring Network (ESBN) monitors soil quality and assesses trends in soil pollution, including pollution caused by heavy metals. EU Member States regularly collect and report data on soil properties and contaminants, enabling the EU to identify areas of concern and take targeted action where necessary. In addition, the Common Implementation Strategy for the Water Framework Directive concerns the monitoring of water quality, including the presence of heavy metals, in surface water and groundwater. As soil and water quality are closely interconnected, monitoring water bodies also provides insights into potential soil contamination sources and trends.

GROUNDWATER FRAMEWORK DIRECTIVE

The Groundwater Framework Directive (2006/118/ EC) provides an overarching legislative framework for protection of groundwater against pollution and deterioration, thus aiming to prevent soil degradation and pollution, including with heavy metals. It emphasizes the importance of identifying and managing risks posed by heavy metal contamination.

CIRCULAR ECONOMY ACTION PLAN

More recently, the EU Green Deal has also addressed the issue with the introduction of its Circular Economy Action Plan, which is intended to promote resource efficiency and waste prevention, including measures to reduce heavy metal pollution. By encouraging recycling, reuse and sustainable production practices, the plan aims to minimize the release of heavy metals into the environment, including soil.

REPORTING

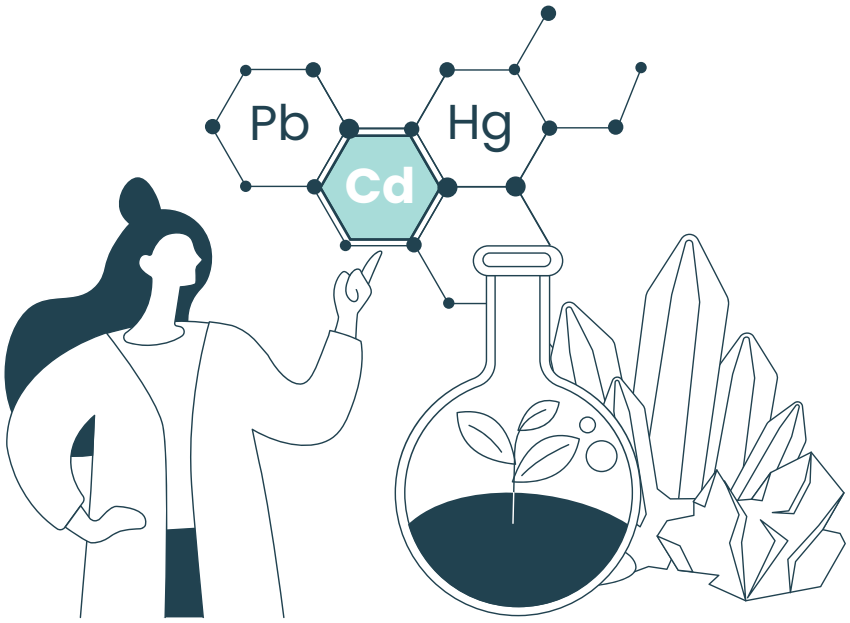
Overall, EU Member States are required to report on the implementation of EU environmental legislation, including measures related to heavy metal pollution in soil, specifically under the provisions of the ESBN. Regular reporting enables the EU to assess compliance with legislative requirements and identify areas where additional action may be needed. On the other hand, the European Commission monitors Member States' compliance with EU environmental legislation and can initiate infringement proceedings against those failing to fulfil their obligations. In cases of significant or persistent non-compliance, the Commission may escalate enforcement actions, including imposing financial penalties.

In conclusion, the EU has implemented a comprehensive framework of legislative measures aimed at preventing, monitoring and managing heavy metal pollution in soil. By establishing standards, promoting monitoring efforts and enforcing compliance, the EU aims to safeguard soil quality, protect ecosystems, and ensure the health and well-being of its citizens. Continued efforts are essential to addressing existing contamination, preventing future pollution and promoting sustainable soil management practices across the European Union.

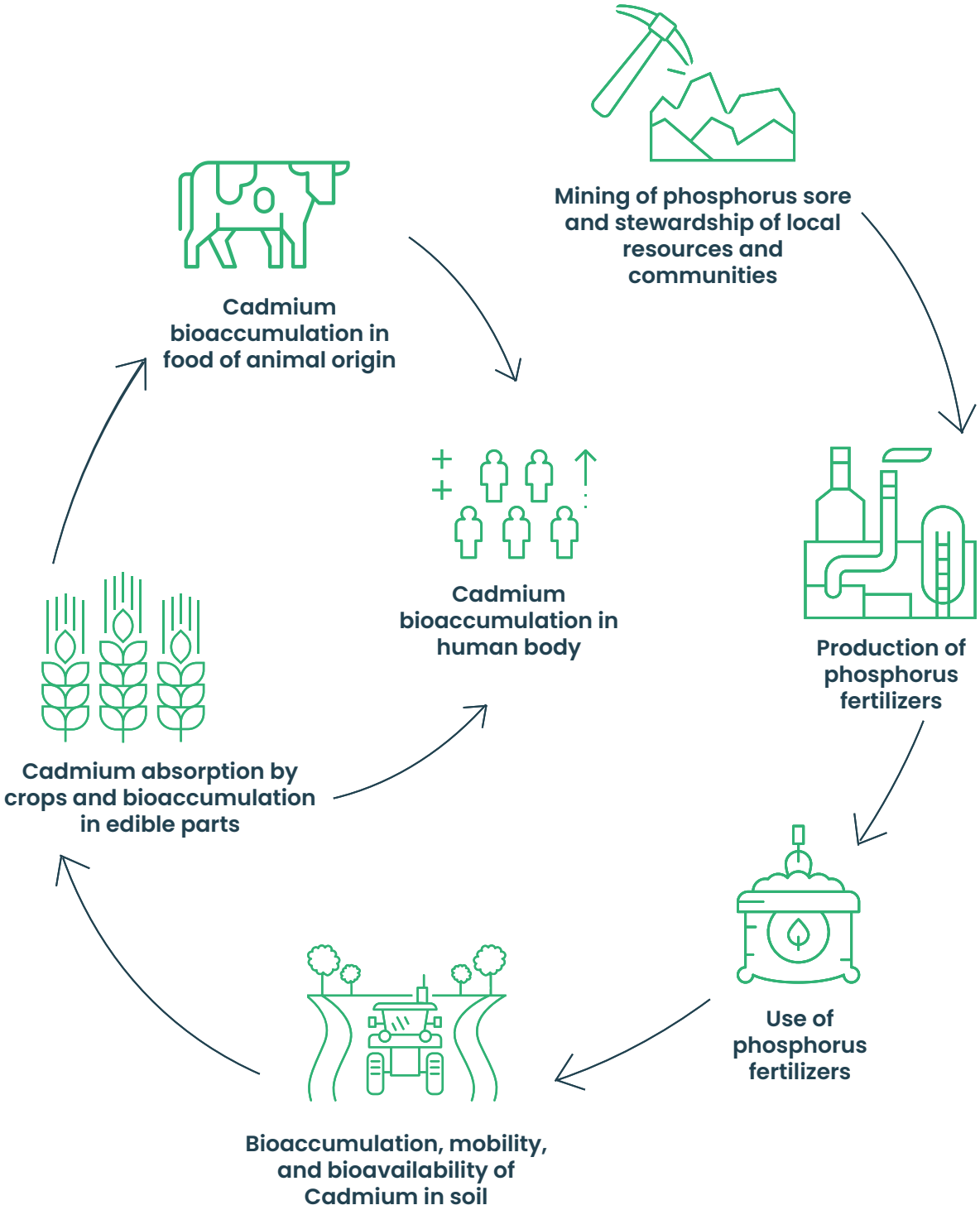
Cadmium: a case study

Cadmium (Cd) is a soft, ductile metal with a silvery-white appearance, belonging to the group of heavy metals, which are characterized by their high molecular weight. While relatively rare in nature, Cd can be released into the environment through various natural processes such as erosion, river transport and volcanic activity. When it comes to human activities, the primary source of contamination stems from the use of high-cadmium phosphate fertilizers, which contribute to both diffuse and point source pollution. Ranked as the third most hazardous environmental pollutant, following mercury (Hg) and lead (Pb), Cd is known for its biopersistence, remaining in organisms for extended periods once absorbed.

Cd also poses a significant threat to both soil health and human well-being. Its presence in agricultural soils is primarily attributed to the intensive use of phosphate fertilizers, which are manufactured from phosphorite and apatite rocks containing Cd along with phosphate dioxide. The quantity of Cd in these fertilizers depends on the Cd concentration in the rocks used. Once applied to soil, Cd binds to organic matter, becoming readily available to plants. European soils are particularly susceptible to Cd accumulation due to specific environmental conditions, including mild temperatures and prolonged summer droughts. Additionally, Cd exhibits high mobility in surface and groundwater, facilitating its rapid spread from localized sources to diffuse contamination.



Crops absorb Cd from the soil, introducing it into the food chain and posing significant health risks to consumers. Common dietary sources of Cd include cereals, nuts, legumes, starchy roots, potatoes and meat. Classified as a human carcinogen since the 1990s, Cd accumulation in the body can lead to kidney dysfunction, liver damage and bone demineralization. To mitigate Cd bioaccumulation and associated health risks, it is crucial to limit Cd content in fertilizers. Fertilizers with low Cd levels, not exceeding 20 mg Cd/kg P2O5, are recommended to help safeguard soil and food safety.



Cadmium pollution

The impact of mineral fertilizers on Cd contamination in agricultural soils and, consequently, on the diets of Europeans is well documented in various studies. Cd, a toxic contaminant, poses severe and often irreversible health risks to humans and natural ecosystems. The primary cause of Cd accumulation in agricultural soils and watersheds is the application of mineral phosphorus (P) fertilizers. In Europe, these fertilizers account for 45% of the total Cd contamination of cropland. Alarmingly, 55% of the average European consumer's dietary Cd intake is linked to Cd accumulation in soil. The long-term consequences of Cd contamination of soil ecosystems remain uncertain. Studies suggest that even low levels of diffuse contamination coupled with efficient Cd transfer from soil to plants can result in Cd concentrations in edible plant parts exceeding safe limits for human consumption. Given these uncertainties, implementing stricter limits to curb Cd accumulation and soil pollution is a prudent solution to the problem of safeguarding European ecosystems and human health.

Factors influencing the accumulation and distribution of heavy metals

Understanding the factors that influence the accumulation and distribution of heavy metals in the environment is crucial for the adoption of effective management and mitigation strategies. This section provides an overview of the diverse factors that play key roles in determining the fate of heavy metals in various environmental compartments, including soil, water and air.

According to a 2002 assessment by the Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE), Cd accumulation in agricultural soil is estimated at around 1% annually. European Member States, after conducting risk assessments, found that phosphate fertilizers contribute between 0.4% and 1.25% of this accumulation due to their Cd content. The literature also highlights how Cd contamination from phosphate fertilizers overlaps with other sources. In 2023, the Joint Research

45%

contamination of cropland by fertilizers

Centre of the European Commission, in its report "Cadmium in the Soils of the EU", concluded that a large number of samples collected in different EU Member States exceeded the normal levels of cadmium in soil.

The bioaccumulation of heavy metals in soil is influenced by various factors, such as their levels, climate, soil properties and agricultural practices, impacting ecological systems and organisms' health. In Europe, for instance, Cd tends to accumulate in surface soil layers, particularly due to mild temperatures and prolonged summer droughts, aided by the facilitation of nutrient absorption by microfauna and root structures. Cd seems to be gradually building up in agricultural soils, with levels surpassing the commonly accepted threshold concentration (1 mg/kg) in samples taken from agricultural and grassland areas.

Some heavy metals, such as Cd and zinc (Zn), have a high transfer rate from soil to plants, and they are both necessary elements for good plant and human development. When the soil lacks an adequate supply of Zn minerals to meet a crop's requirements, the resemblance between the two elements prompts the plant to absorb Cd instead of Zn. For instance, there is a notable overstepping of the critical threshold across the EU soil landscape, particularly for copper (Cu) (23%) and Zn (18%). Mediterranean countries exhibit notably elevated Cu levels compared with the critical threshold for soil biodiversity.

Effects of cadmium contamination on soils

Contamination with heavy metals poses a notable challenge for plants, potentially leading to cytotoxic and genotoxic impacts, as well as hindering growth and reproductive capabilities. The primary factors affecting soil quality stem from the introduction of heavy metals in fertilizers, which can adversely impact soil biodiversity and, particularly in the case of Cd, compromise food quality.

The combination of widespread, low-level soil contamination and the effective transfer of Cd from soil to plants implies that even with minimal contamination levels and the absence of visible toxicity symptoms in plants, the edible parts of plants could accumulate Cd beyond permissible limits for human consumption. The main effect of heavy metals, such as Cd, on human health is kidney, pulmonary, cardiovascular and musculoskeletal diseases.

A recent analysis of topsoils concluded that the Cd content in EU agricultural soils is of concern and that exposure to Cd hotspots should be further limited. It is crucial to mitigate Cd accumulation in soils by utilizing phosphate fertilizers with low Cd concentrations.

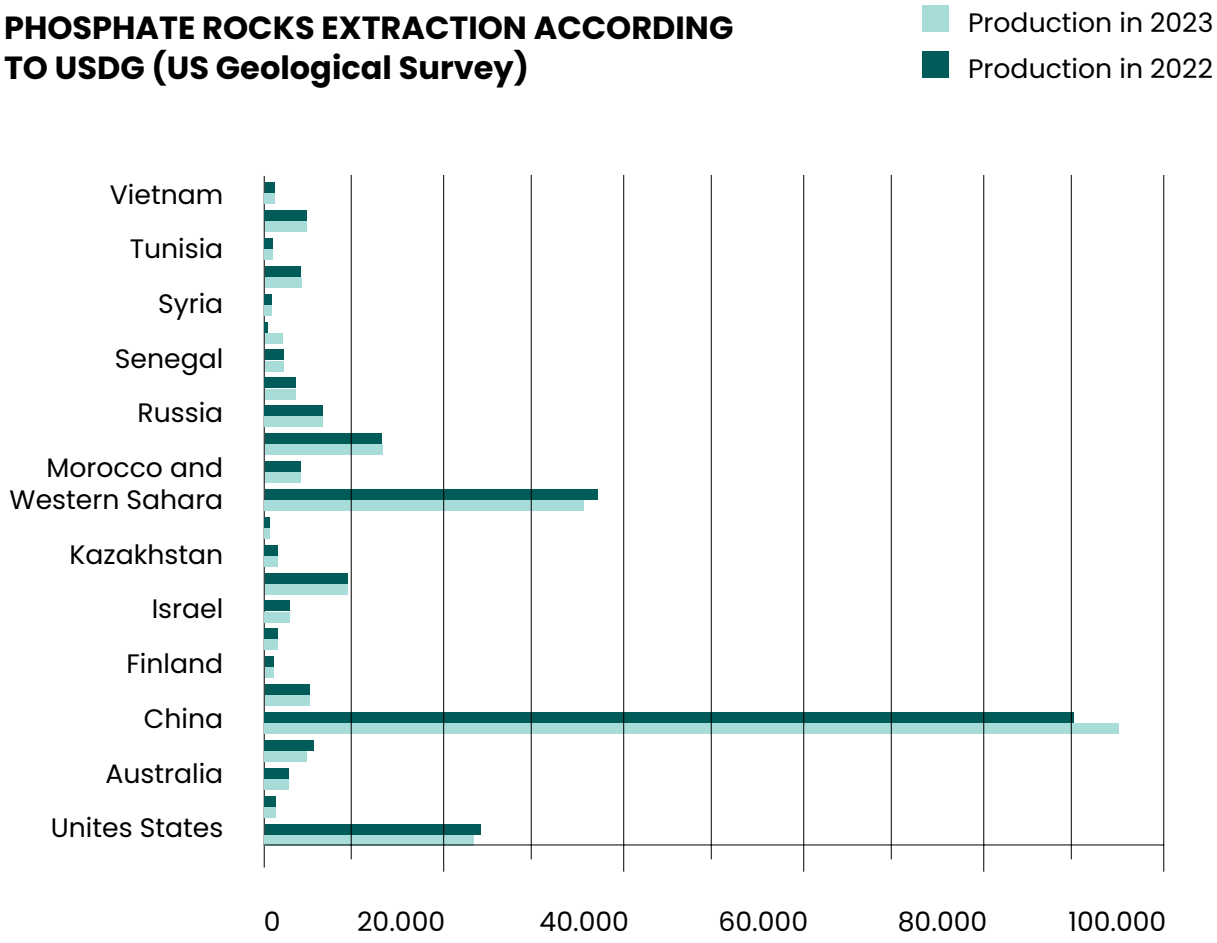
Accumulation of cadmium in soil

In 2002, the CSTEE estimated that the annual net accumulation of Cd in soil is about 1% of the amount already present in agricultural soils. As mentioned previously, the European Member States that conducted specific risk assessments concluded that the annual net accumulation by phosphate fertilizers alone (with an estimated Cd content of 60 mg/kg P2O5) is between 0.4% and 1.25% of that already present in agricultural soils.

The literature also shows how the contribution of Cd contamination from the application of phosphate fertilizers to agricultural land dangerously overlaps with that stemming from other sources.

An estimate of Cd contamination in Switzerland in 1990 shows that about 1.1 tonnes of Cd was added to agricultural

PHOSPHATE ROCKS EXTRACTION ACCORDING TO USDG (US Geological Survey)



soils annually through mineral fertilizers; 0.5 tonnes, through sewage sludge; 1 tonne, through organic fertilizers; and 8.9 tonnes, through atmospheric deposition.

Factors such as Cd levels, climate, soil pH, organic matter, salinity, tillage, macro- and micronutrients, type of parent rock, crop species and varieties play essential roles in soil bioaccumulation and result in long-term effects on ecological systems and the health of living organisms.

Monitoring soil status according to the European Environment Agency

According to the latest data published by the European Environment Agency, there are 2.8 million contaminated or potentially contaminated sites in Europe, with heavy metals being the most frequent contaminants.

The reported information shows that Cd is an extremely dangerous metal present in mineral phosphorus fertilizers. If organic fertilizers are not properly controlled, they may also introduce a variety of organic contaminants and heavy metals. Examples of these organic contaminants include compost, sewage sludges, manure and bio-waste.

The impact of cadmium on the environment

The accumulation of Cd in the soil through the use of fertilizers can affect crops and ultimately animals and humans.

Since 2001, the United Nations Environment Programme (UNEP) has been mandated to address the environmental and health risk of lead and Cd, upon advice from the working group on lead and cadmium. According to the UNEP, Cd, which is toxic to plants, animals and microorganisms, is released by various natural and anthropogenic sources into the atmosphere as well as terrestrial and aquatic environments (fresh- and saltwater environments).

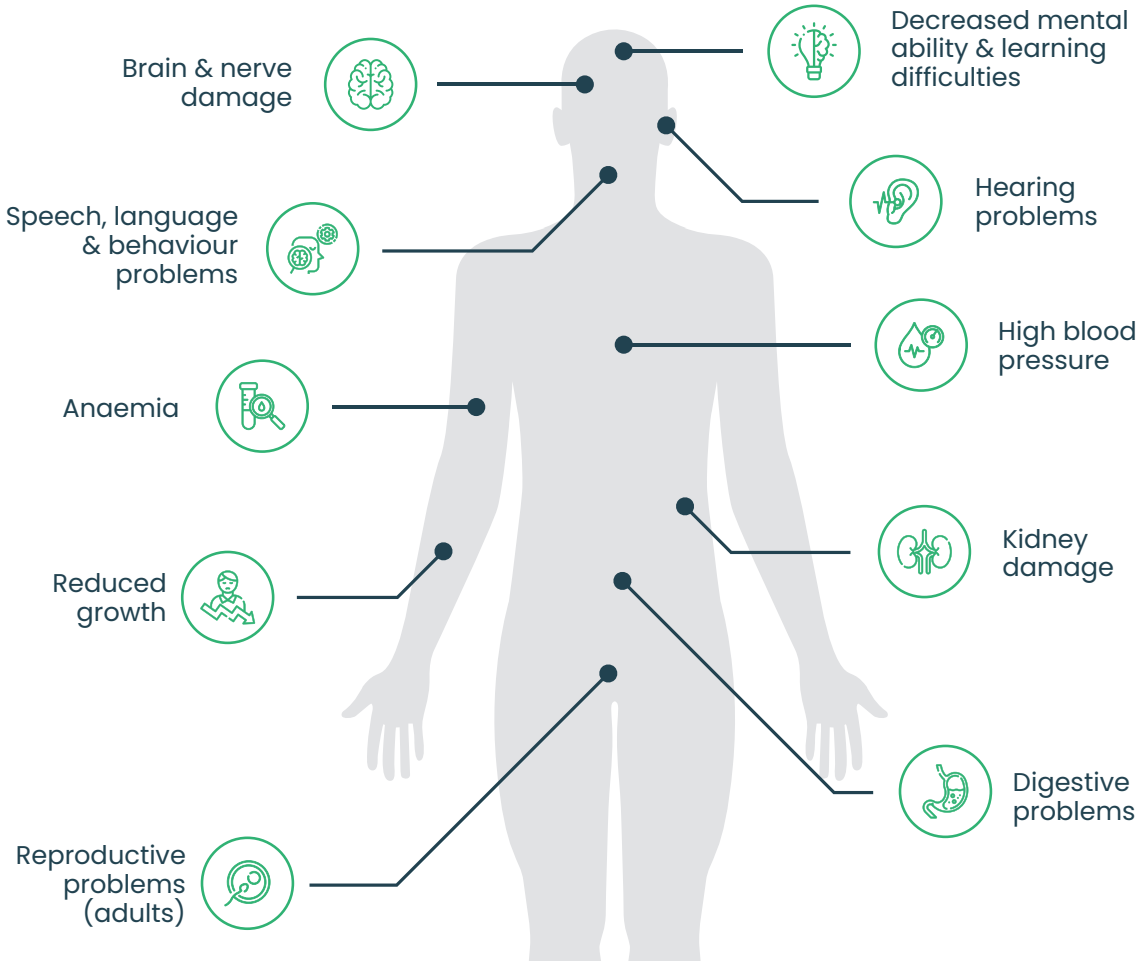
Cd can accumulate in both plants and invertebrates. Plants and soil microorganisms in terrestrial habitats are more susceptible to Cd than soil invertebrates. Invertebrate predators in soil may transmit Cd into the food chain, which means that there is a potential risk of secondary poisoning from worms to higher trophic levels (mammals or birds). Cd is a pollutant that enters the human food chain through plant accumulation.

The measured and predicted levels of Cd in some parts of Europe are higher than what is considered to be harmful to terrestrial ecosystems.

The impact of cadmium on human health

The scientific literature identifies Cd as a non-essential element for living organisms. Cd is primarily toxic to the kidneys and the liver, can cause bone demineralization and is classified as a human carcinogen (IARC, 2021; EFSA, 2021; ANSES, 2021).

Foods are the primary source of Cd exposure. Cereals, vegetables, nuts and legumes, starchy roots and potatoes, and meat are the major contributors to human exposure. High concentrations also occur in algae, fish and seafood, dietary supplements, mushrooms and chocolate. Given the lower average intake, these are not usually significant sources of exposure. However, chocolate does become relevant when it comes to intake by children.



What is the EU policy on cadmium in phosphate-based fertilizers?

Current EU laws on Cd limits are specified in Regulation 2019/1009 on fertilizing products, in force since July 2022. This regulation follows up on several efforts, undertaken since the 1990s, to reduce heavy metal concentrations in European ecosystems through the regulation of the use of heavy metals in, inter alia, fertilizing products.

Regulation 2019/1009 harmonized rules for the marketing of several fertilizing products in the EU, making significant changes to the rules on inorganic fertilizers for the first time since 2003, when the so-called EC fertilizers category was created by Regulation 2003/2003.

Before the enactment of this regulation, Member States could implement limits at their own discretion, with values for Cd at the time ranging between 20 and 90 mg/kg P205 (phosphate anhydride, or phosphorus pentoxide). Under the new regulation, limits were set for several contaminants present in fertilizers, including heavy metals such as Cd. The limit for Cd in phosphate fertilizers was thus set at 60 mg/kg P2O5.

Furthermore, the regulation introduced the option for fertilizer producers to label their products as having "low cadmium (Cd) content" or to visually represent this information if the Cd content was 20 mg/kg of P2O5 or less. This provision aimed to incentivize the production and use of

fertilizers with lower Cd levels, promoting environmental sustainability.

The present regulation must undergo a mandatory review procedure by 2026, when stricter limits will be explored.

Safer Phosphates proposes a capping of Cd values in fertilizers at 10–20 mg/kg P2O5 to control agricultural soil pollution, plant contamination and human exposure.

Capping Cd values in fertilizers at 10–20 mg/kg P2O5 would be subject to the completion of a feasibility assessment by the EU. The conclusions of such an assessment will be paramount for determining the new limits for both Cd and other heavy metals in fertilizers.

Although past developments in environmental and agricultural policies at the EU level would suggest a preference for stricter limits by European authorities, recent developments on agricultural policy, including through actions initiated by stakeholder-led organizations, suggest that a less stringent outcome remains possible.

What are the current cadmium limits?

A transparent and predictable legal framework, achieved through harmonized rules, is essential for promoting healthy competition and for increasing awareness of the risks and risk mitigation strategies across the value chain. This framework benefits various stakeholders, including agricultural technology providers, farmers, and food processors and distributors. The EU would like to be considered the most active region in terms of soil protection and conservation, but despite the political importance attached to the issue, soil-related measures can be effective only if Member States implement and support them.

In 2022, the EU set a maximum threshold for Cd in fertilizers, which is currently 60 mg/kg P2O5, according to EU Regulation 2019/1009. These limits are intended to protect consumers from excessive Cd exposure and to ensure the safety of agricultural produce.

While the EU sets overarching limits, individual Member States may also impose stricter regulations based on their specific environmental and health considerations. This decentralized approach allows Member States to tailor regulations to their unique circumstances while upholding the EU's overall standards.

The EU Member States are mandated to adopt the thresholds for Cd in fertilizers as set by the EU. At the time of publication, 12 Member States – e.g., Italy, the Netherlands and the Nordic countries – had adopted Cd limit values of no more than 50 mg Cd/kg P2O5. On the other hand, eight Member States e.g., France and Greece – had Cd limits of 60 mg Cd/kg P2O5. Concurrently, Austria and Belgium are adapting their higher Cd limit values.

Although there are limits on the levels of Cd in fertilizers, required levels in terms of soil contamination have still not been harmonized. Legally established limit values for agricultural lands might vary significantly from one Member State to another, starting from 0.5 mg/kg-1. Still, the Finnish and Swedish systems, using a threshold of 1 mg/kg-1, are the most used. For a soil to be considered "contaminated", a concentration of 3 mg/kg-1 is considered sufficient. This means that any concentration above this limit could harm a person's health.

Scientific studies

Understanding heavy metal contamination in soil

Heavy metals are characterized by their non-biodegradability and accumulation in the environment. Heavy metal pollution is a pressing environmental issue exacerbated by human activities such as mining, farming and industrial operations, which release heavy metals into the environment. These metals contaminate soil, posing risks to crops, altering the food chain and endangering human health. While efforts to reduce emissions and regulate waste disposal have led to a decrease in heavy metal loads reaching soils in some regions, past contamination persists, particularly in areas with a history of agricultural, industrial or mining activities, with potential long-term impacts on soil health and human well-being.

The expansion of industrialization and modern agricultural practices has contributed significantly to widespread soil contamination with heavy metals globally. Factors such as mineral extraction and handling techniques influence the introduction and mobility of pollutants and heavy metals in the environment, exacerbating the issue of contamination. Contamination with heavy metals is particularly harmful to human health due to their potential bioaccumulation (i.e., concentration in the human body due to exposure to contaminated sources) and biopersistence (i.e., their prevalence in organisms for a long period of time).

Geography

With 90% of phosphorus reserves concentrated in five countries and over half of the world's potassium reserves found in just three countries, the reliance on these limited resources heightens the risk of contamination. Social factors, including conflicts, exacerbate the situation, leading to acute energy and fertilizer crises. In 2022, for instance, supply shortages left approximately 40% of the world's potassium supply unavailable, triggering price hikes and putting farmers' ability to access essential nutrients at risk. Additionally, the reduced availability of natural gas further constrains the fertilizer industry, exacerbating supply shortages, particularly of nitrogen.

Gaps

In recent decades, significant advances in research, mapping and monitoring of soil pollution have been observed, particularly in the European Union. These advances are in line with the aforementioned EU legal instruments intended to reduce soil contamination and mitigate the negative impact of heavy metals. Nevertheless, there remain significant chronological gaps in recent efforts that may lead to delayed accounts on the development, whether positive or negative, of soil contamination levels. For a proper understanding of the situation of European soils, as far as contamination from Cd and other heavy metals is concerned, further studies and more dedicated, continuous monitoring are of paramount importance.

LUCAS soil survey finds cadmium contamination in European topsoils

In the context of the LUCAS (Land Use and Coverage Area frame Survey) project, led by the European Commission Joint Research Centre in Ispra, a study was recently conducted on the presence of Cd in over 20,000 samples of topsoils from the EU and the United Kingdom. The analysis found a Cd concentration of above 1 mg/kg (considered to be the limit for risk assessment) in 5.5% of European topsoils. The Cd distribution is not balanced across Europe, with higher concentrations being observed in countries in North-western and Central Europe, including the United Kingdom. Controlling for natural and anthropogenic factors, the authors of the study used machine learning to develop detailed maps of Cd distribution and contamination.

According to the study, it is clear that fertilization remains the primary source of Cd input into soils, with leaching being the main output. The study supports the Commission's proposal to establish lower Cd limits in phosphate fertilizers, specifically highlighting that the priority should be addressing hotspots with Cd levels exceeding 1 mg/kg-1 and agricultural areas subject to intensive fertilization.

INSOP–INFA and international actions to address Cd pollution

The persistent relevance of soil pollution and its impacts in debates on agriculture and environmental health led to the establishment of several dedicated technical and political bodies by the United Nations Food and Agriculture Organization (FAO). The two most active in the field of Cd contamination are the International Network on Soil Pollution (INSOP) and the International Network on Fertilizer Analysis (INFA), both part of the Global Soil Partnership initiative.

INSOP was created to foster knowledge-sharing, exchange experiences and best practices and strengthen competencies, in both the public and private sectors, including academia, to combat soil pollution, restore affected areas and advance towards the zero-pollution global target. INSOP is divided into six working groups, each dealing with one part of the analysis of soils, including mapping, monitoring and exploring the nexus with agriculture, food quality and water pollution. INFA, on the other hand, is an international network of laboratories working in fertilizer analysis that was set up to address the need for standardized methodologies and enhanced capacities. INFA counts on nearly 100 laboratories across all continents.

Due to the significant intersection between the topics covered by INSOP and INFA, the two bodies often work on joint projects. Cd pollution in soils was discussed during the first INSOP meeting, held in 2023. The most recent INSOP–INFA meeting on fertilizer quality assessment featured participants from 23 European countries, up from 15 at the previous meeting. The two bodies agreed to focus their efforts on identifying key fertilizer sources and methods for analysis as well as optimizing standard operating procedures (SOPs) for evaluating heavy metal content in phosphate fertilizers. Agreements were struck between members to harmonize the SOPs for Cd in mineral fertilizers, including rock phosphate fertilizers. INSOP and INFA also plan to raise awareness of the safety of various fertilizers in terms of the environment and human health.

The advantages and importance of harmonization in fertilizer analysis on a global scale are crucial. Laboratories benefit from harmonization through the establishment of a robust and consistent methodology, ensuring the production of accurate and precise results that are comparable across different facilities. This harmonization not only enhances the quality of fertilizer analysis but also fosters better decision-making processes based on reliable data. Moreover, harmonization promotes capacity-building, particularly in developing nations, by providing access to established practices and expertise.

Policy recommendations

In conclusion, the heavy metal contamination of soils in Europe poses a significant threat to soil health, agrifood systems and public health.

At the Safer Phosphates Foundation, we dedicate our work to promoting eco-friendly fertilizers free of heavy metals; as such, it is imperative that we call on policymakers to address this pressing issue.

To safeguard soil health and fertility, as well as ensure food safety and human health, we propose a comprehensive set of policy recommendations:

1. **Harmonized European thresholds:** Implement stringent, harmonized thresholds for heavy metals in fertilizers across Europe, with a focus on contaminants like Cd. This would protect vulnerable environments and populations while promoting sustainable agricultural practices.

2. **Improved farming practices:** Encourage and incentivize farmers to adopt and continually improve their use and management practices, including the utilization of fertilizers with low levels of heavy metals and sustainable soil management techniques.

3. **Collaborative efforts:** Foster collaboration between adjacent sectors to contribute to ongoing improvements through voluntary measures. This includes engaging with fertilizer manufacturers, agricultural associations and environmental organizations to develop and promote sustainable solutions.

4. **Regulatory revision:** Review and revise existing regulations, such as EU Regulation 2019/1009, to ensure precise labelling for phosphorus fertilizers. This would enhance transparency and enable consumers to make informed choices.

5. **Tolerance thresholds:** Call on the relevant authorities to set tolerance thresholds for heavy metals in fertilizers at the lowest feasible levels, such as 20 mg/kg for Cd. This would drive the industry towards the adoption of cleaner production methods and reduce the prevalence of contaminants in fertilizers.

6 **Research and development:** Invest in research and development initiatives focused on fertilizer production methods, soil health and fertility. This would facilitate the development of innovative solutions to prevent or mitigate the harmful effects of heavy metal contamination on soil and water resources.

7 **Investment:** Invest in technologies that can remove Cd and other heavy metals from soils and recycle them.

By implementing these policy recommendations, we can mitigate the adverse impacts of heavy metal contamination on soil health, agrifood systems and public health in Europe. It is crucial for policymakers to prioritize the protection of our soils and ecosystems, ensuring a sustainable and resilient future for generations to come. Together, we can build a greener and healthier Europe, free from the scourge of heavy metal pollution in our soils.

Notes

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study that aims to measure population exposure to heavy metals, focusing on dietary habits and chronic diseases. The results showed that cadmium was present in 100% of the adults and children participating in the study. In children, breakfast cereal consumption increased cadmium intake, mainly due to cadmium-rich phosphate fertilizers used in conventional agriculture and daily consumption of these cereals. In non-smoking adults, consumption of shellfish was the primary source of exposure. See https://www.santepubliquefrance.fr/etudes-et-enquetes/esteban .

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