Toxics Link
for a toxics-free world

Lead in TURMERIC

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Pb
Lead
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About Toxics Link

Toxics Link is an Indian environmental research and advocacy organisation set up in 1996, engaged in disseminating information to help strengthen the campaign against toxic pollution, provide cleaner alternatives, and bring together groups and people affected by this problem. Toxics Link's Mission Statement "Working together for environmental justice and freedom from toxics. We have taken upon ourselves to collect and share both information about the sources and the dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives for India and the rest of the world." Toxics Link has unique expertise in areas of hazardous, medical, and municipal wastes, international waste trade, and the emerging issues of pesticides, Persistent Organic Pollutants (POPs), hazardous heavy metal contamination, etc. from the environment and public health point of view. We have successfully implemented various best practices and have brought in policy changes in the aforementioned areas apart from creating awareness among several stakeholder groups.

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1. Introduction

1.1 Background

Lead (Pb) is a toxic heavy metal that occurs naturally in the Earth's crust. It possesses several advantageous properties, including high density, corrosion resistance, softness and malleability, good electrical conductivity, low melting point, and durability (Mishra et.al., 2025). These characteristics have contributed to its widespread use across various industrial sectors, including lead-acid batteries, paints, pigments, ceramics, gasoline additives, plumbing materials, cables, and ammunition (Boldyrev, 2018). However, owing to the significant health and environmental risks associated with lead exposure, its use has been phased out or restricted in many products worldwide. In addition, increasingly stringent regulations are being framed and implemented to control lead emissions from industrial and other anthropogenic sources to prevent contamination of soil, water, and air (Annex-III) (Olufemi, et.al., 2022).

Human exposure to lead occurs through multiple pathways, including inhalation of contaminated dust and fumes, ingestion of contaminated food and water, and occupational exposure associated with activities such as mining, smelting, battery manufacturing, and informal recycling of lead-acid batteries (WHO, 2015).

Among non-occupational exposure pathways, dietary intake has emerged as a significant source of lead exposure. Food contamination may occur through polluted soil and irrigation water, atmospheric deposition, contaminated processing equipment and packaging materials, as well as the intentional or unintentional addition of lead-containing substances during processing (Wang et.al., 2019).

In recent years, several studies have reported elevated levels of lead in turmeric sold in the Indian market (Forsyth, et.al., 2024; Shahet.al., 2025; Forsyth, et.al., 2026), raising serious public health concerns due to the extensive use of turmeric in cooking, traditional medicine, and religious practices in India and other Asian countries.

Previous studies have suggested that lead contamination may occur at different stages of the supply chain, including post-harvest handling and processing (Forsyth, et.al., 2019; Rees, 2020; Forsyth, et.al., 2024; Gafner, et.al., 2026). Therefore, it is important to understand whether lead contamination originates during cultivation or is introduced after harvest.

At the same time, it is important to understand the contribution of environmental factors that may also elevate lead levels in turmeric. Contaminated agricultural soil, irrigation water, atmospheric deposition from industrial and vehicular emissions, use of contaminated fertilizers and pesticides, and post-harvest handling and processing practices may all contribute to lead contamination. Therefore, assessing both intentional adulteration and environmental sources is essential for effectively addressing lead contamination in turmeric and for developing appropriate regulatory and mitigation measures.

1.2 Health Impact of Lead

Lead exposure can affect every organ in the human body. Children and pregnant women are vulnerable to lead exposure and may develop severe and irreversible health effects. According to the World Health Organization (WHO, 2024), lead exposure is one of the most important health concerns globally. Since it can contribute burden of diseases and developmental disorders.
Similarly, as per International Agency for Research on Cancer (IARC) (ATSDR, 2019). classified lead a carcinogen to human. (Group 2A/IIA).
Children are vulnerable to lead exposure since it gets absorbed easily in their body as compared to the adults. Once it gets absorbed in the body it can results in reduced intelligence quotient (IQ), impaired cognitive development, learning disabilities, reduced attention span, behavioural changes, hyperactivity, aggression, and poor academic performance. Many of these cases occurs silently without clinical symptoms, making lead exposure a major threat to the public health.

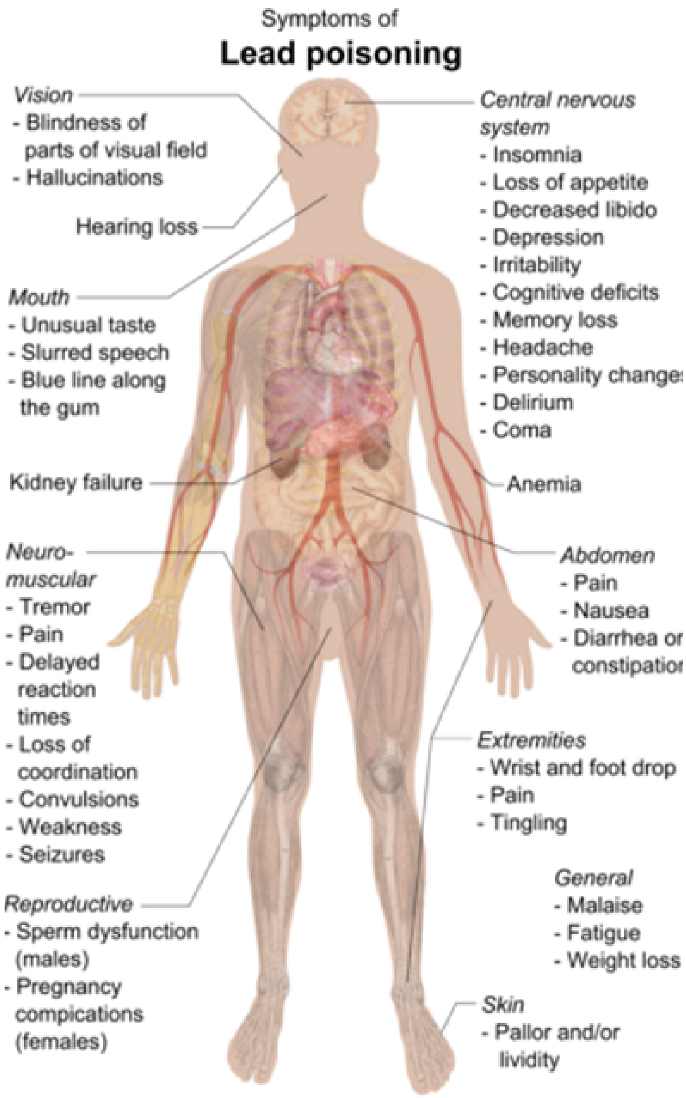

Figure 1. Health impact of lead exposure

Several scientific studies have reported that there is no known safe blood lead level in children and it can have adverse neurodevelopmental impacts even at very low level of concentration. Furthermore, lead exposure to the children can cause anaemia, hearing impairment, delayed growth, weakened immunity and damage to the kidney and other organs. Severe exposure can lead to seizures, coma, and even death.
In adults, long-term lead exposure can cause hypertension, cardiovascular diseases, kidney dysfunction, reproductive disorders, nerve damage, memory problems, and adverse pregnancy outcomes. In addition to this, lead can also cross the placental barrier, exposing the developing foetus during pregnancy and increasing the risk of premature birth, developmental delays, and reduced birth weight.

Table 1. Health impacts due to lead exposure

Age Group	Early symptoms	Chronic exposure impacts
Adults	Fatigue, abdominal pain, mood changes, sleep disturbances, and reduced libido	Kidney dysfunction, anaemia, and in extreme cases, encephalopathy marked by confusion, seizures, or coma
Children	Impair cognitive development, behaviour and attention span	Learning disabilities, delayed growth, hyperactivity, or social withdrawal. In extreme cases, neurological damage can be permanent

1.3 Lead Contamination and Food Chain

There are increasing reports and scientific evidence indicating that food and dietary items are emerging as key and under-recognized pathways of lead exposure. Contamination of food products can occur through environmental pathways such as polluted soil, water, and air, as well as during processing, storage, packaging, and through intentional adulteration practices. Multiple factors contribute to lead contamination in the environment and its subsequent entry into the food chain, including emissions and waste from lead-acid battery recycling industries, paint manufacturing, and other industrial activities involving lead-containing materials and products. Apart from the industrial activities, municipal solid and liquid waste released from the households can contribute to lead contamination in soil and water, which may affect agricultural fields and crops. Recent Study conducted by Toxics Link (2025) have documented elevated levels of lead contamination in soil.

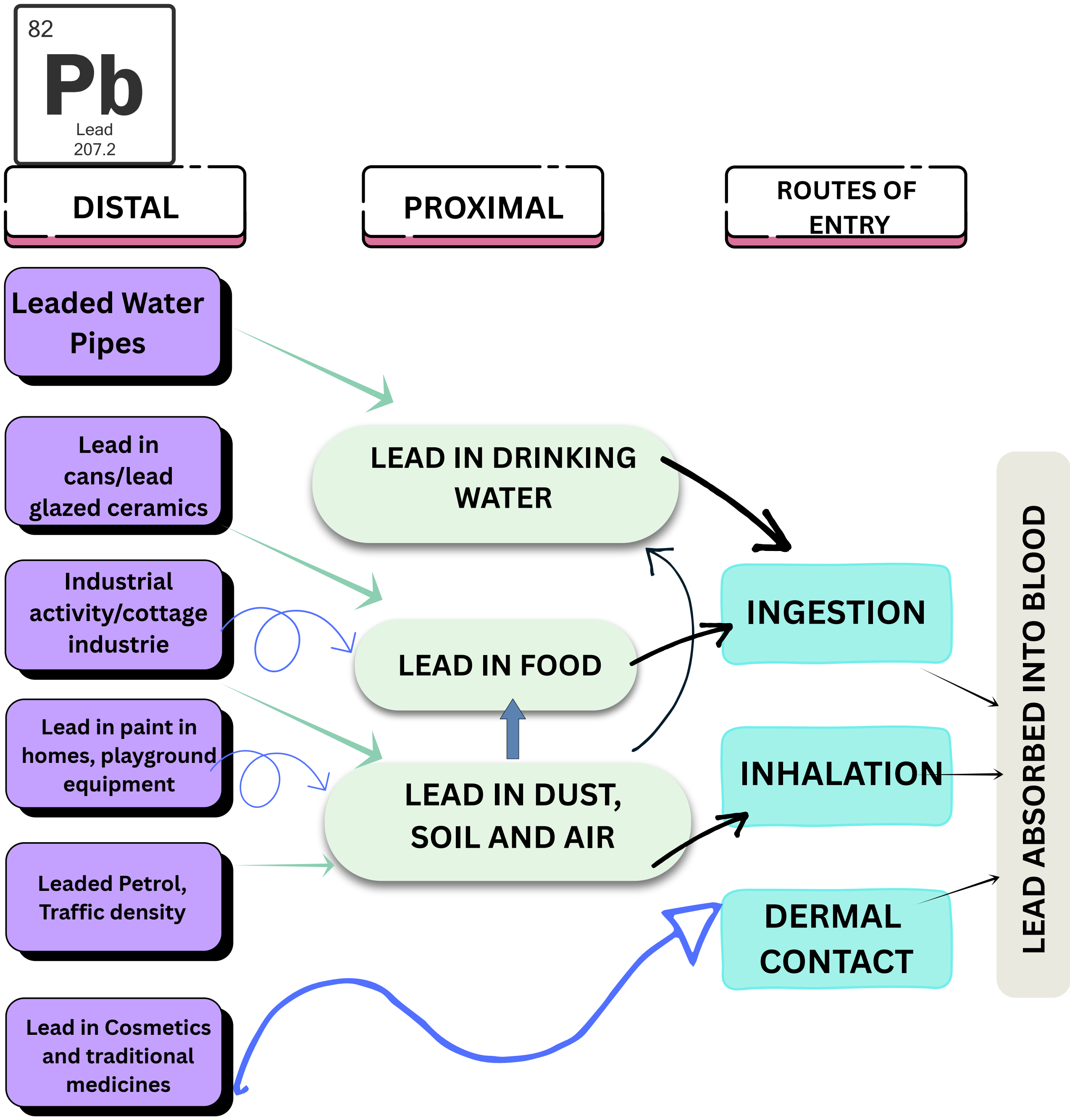

Figure 2. Major sources and routes of environmental lead exposure (Adapted from WHO 2021)

Spices, leafy vegetables, and turmeric are among the common food items that have gained increasing attention as potential sources of lead contamination (Gleason, et.al., 2014). Research studies have shown that lead present in contaminated soil can bioaccumulate in agricultural products and subsequently enter the human body through the food chain, leading to adverse health effects. Although plants are capable of accumulating significant quantities of lead ions from soil, a major proportion of the lead burden generally remains concentrated in the roots, with limited translocation to stems, leaves, and fruits (Gupta, et.al., 2024; Mishra, et.al., 2025).
Kappel et al. (2019) reported a case study of lead poisoning in a 2-year-old boy and a 9-month-old girl linked to the consumption of contaminated turmeric, with venous blood lead levels (BLLs) reaching up to 48 µg/dL, significantly higher than the reference level of <5 µg/dL Kappel, et. al., 2021).

The study highlighted the serious public health risks associated with lead-adulterated spices and the need for stricter monitoring and regulation of food products.

Toxics Link (2003), in collaboration with Imperial College London, the Indian Agricultural Research Institute, Delhi University, and Banaras Hindu University, carried out one of the first studies in India investigating heavy metal contamination in vegetables. The study reported that spinach (palak) grown in the peri-urban areas of Delhi and Varanasi was contaminated with lead and zinc.

Findings revealed that, out of 222 spinach samples tested for lead, nearly 73% contained lead concentrations exceeding the permissible limit of 2.5 mg/kg prescribed under the Prevention of Food Adulteration (PFA) Act, 1954. The study highlighted the risks associated with cultivation of vegetables in contaminated environments, particularly in areas impacted by industrial emissions, wastewater irrigation, and urban pollution.

Several other studies from India have also reported elevated concentrations of lead in agricultural products. Kumar et al. (2022) reported lead concentrations in cereals ranging from 2.22 to 4.04 µg/g. More recently, Manjunatha et al. (2025) detected lead concentrations up to 37.75 mg/kg in vegetable samples collected from Bengaluru city. The study identified atmospheric deposition and contaminated irrigation water as major contributors to lead contamination in the analysed samples.

Studies from India and other countries have also reported lead contamination in commonly used spices, particularly turmeric. In some instances, turmeric samples were found to contain extremely high lead concentrations of up to 6504 mg/kg, far exceeding the Indian safety limits (Forsyth, et.al., 2024).

Other researchers have reported lead concentrations in turmeric ranging from 5 to 2274 µg/g and associated the contamination with the illegal use of lead chromate, a yellow pigment sometimes intentionally added to enhance the colour and market appeal of turmeric.

In addition to turmeric, several scientific studies have raised concerns regarding lead contamination in spices such as cinnamon, ginger, and black pepper, highlighting the broader food safety and public health implications associated with contaminated spices (Alawadhi, et.al., 2024).

These studies highlight the need to include food as an important pathway in assessing lead exposure pathways underscoring the need to strengthen monitoring and regulation across the food supply chain.

Issue of Lead in Turmeric

Lead contamination in turmeric has emerged as a major food safety concern in India. Several studies have reported elevated levels of lead in turmeric samples collected from local markets, with contamination frequently linked to the intentional addition of lead chromate to enhance colour and improve market value. Since turmeric is consumed daily in a large number of households, such adulteration can substantially increase dietary lead exposure and pose serious health risks, particularly among children and other vulnerable populations (Forsyth, et.al., 2019; Rees, 2020; Forsyth, et.al., 2024).

These findings raise critical concerns regarding food safety, supply chain traceability, and the effectiveness of regulatory enforcement mechanisms. In addition to the significant public health implications, lead adulteration in turmeric can undermine consumer confidence and adversely affect India's reputation and competitiveness in international spice markets. Strengthening surveillance systems, enhancing laboratory testing capacity, improving traceability across the supply chain, and ensuring strict compliance with food safety standards are essential measures to safeguard public health and protect the long-term sustainability of India's turmeric trade and exports.

2. Rationale of the study

Several studies have highlighted extensive Lead presence in the turmeric sold in the Indian market. Brown et al (2022) reported mean lead concentration of 114.6 ppm in turmeric samples collected from Bihar. Similarly, Forsyth et al (2024) have collected turmeric samples from Bihar and found lead in turmeric ranging between 5 to 2274 ppm, identifying adulteration with lead chromate as a major source of contamination.

Recent studies have reported that lead chromate is the common sources of lead contamination in turmeric which is added to enhance its bright yellow colour and increase market value (Forsyth, et.al., 2019; Forsyth et.al., 2024). Although the Food Safety and Standards Authority of India (FSSAI) has prescribed a maximum permissible limit of 10 mg/kg for lead in turmeric, the continued detection of high lead levels raises concerns regarding enforcement and monitoring within the supply chain.

The present study is primarily aimed at understanding the source of lead contamination reported in turmeric powder sold in markets. To achieve this, raw turmeric rhizomes were collected from agricultural fields across different parts of the country and analysed for lead content. Hence determination of lead in these samples will be critical in establishing the source of lead contamination in Turmeric sold in Indian market.

3. Methodology

Thirteen raw turmeric samples were collected directly from the farms of six states. The samples were sent to the NABL-certified M/s Vimta Labs Ltd, Noida for analysis of lead. The samples were tested by the AOAC.2015.01 protocol using Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

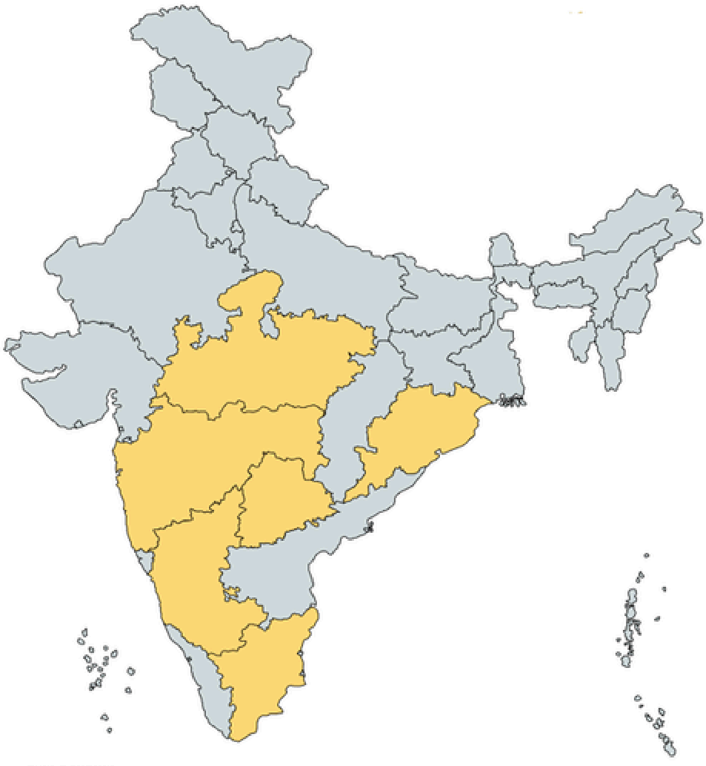

Figure 3. Sampling locations

4. Results & Discussion

In the current study lead was found in range between LOQ-0.05 to 1.87 mg/kg (ppm). The findings indicate that turmeric collected directly from farms generally contains comparatively low levels of lead which is perhaps due to Lead presence in earth crust. Most samples showed lead concentrations below 0.5 mg/kg, while only one sample recorded a comparatively higher concentration of 1.87 mg/kg. All detected levels were below the maximum permissible limit of 10 ppm set by the Food Safety and Standards Authority of India (FSSAI), indicating compliance with existing regulatory standards at the farm level.

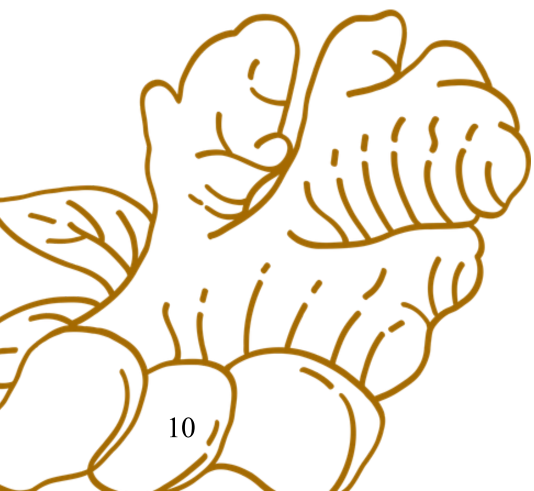

Table 2. Lead concentration in Raw Turmeric

Sr. No.	Sample ID	Results (mg/kg)
1	TL/Pb/MH-Turmeric-01	0.07
2	TL/Pb/MH-Turmeric-02	0.06
3	TL/Pb/MH-Turmeric-03	0.06
4	TL/Pb/HY-Turmeric-04	0.17
5	TL/Pb/HY-Turmeric-05	0.14
6	TL/Pb/TN-Turmeric-06	0.09
7	TL/Pb/TN-Turmeric-07	0.07
8	TL/Pb/OD-Turmeric-08	0.5
9	TL/Pb/OD-Turmeric-09	1.87
10	TL/Pb/KR-Turmeric-10	BLQ (LOQ-0.05)
11	TL/Pb/KR-Turmeric-11	BLQ (LOQ-0.05)
12	TL/Pb/MP-Turmeric-12	0.11
13	TL/Pb/OD-Turmeric-13	0.32

*BLQ; Below the Limit of Quantification; LOQ; Limit of Quantification

The findings of the present study suggest that the agricultural produce of turmeric from the various states does not provide evidence of lead presence in significant quantities. The low levels of lead detected appear to represent only background contamination levels. Sources such as soil and irrigation water appear to have little or no significant contribution to contamination in the produce. The findings can be further supported by previous studies, including a large South Asian study analysing 356 turmeric samples comprising 180 dried turmeric root samples. The study reported that elevated lead levels were primarily associated with lead chromate adulteration during post-harvest stages rather than contamination from agricultural sources. Collectively, these studies suggest that turmeric at the cultivation stage generally contains low or negligible lead contamination (Forsyth, et.al., 2024).

These findings underscore the need for further sampling and testing of turmeric powder sold in Indian markets. This is a public health safety concern which requires immediate attention and in-depth investigation by the FSSAI to identify the root cause of such non-compliant product being sold to large consumer base for daily consumption. Stronger monitoring and regulatory oversight of processing and marketing stages, improved traceability across the turmeric supply chain, and stricter enforcement of food safety standards are required to prevent adulteration. Addressing these gaps is essential to protect public health, maintain consumer confidence, and safeguard the reputation of Indian turmeric in both domestic and international markets.

Limitations of the study:

- Insufficient sample size may have constrained the ability to establish broader trends or achieve statistical significance.
- Soil samples were not tested for lead concentration to correlate with the load in turmeric.

5. Recommendations

- Strengthen routine monitoring and testing of turmeric and other spice products at wholesale and retail markets to enable early detection of lead contamination and ensure compliance with food safety standards.
- Improve traceability systems across the turmeric supply chain, from cultivation and procurement to processing, packaging, and market distribution, to identify critical points where contamination or adulteration may occur.
- Conduct targeted inspections and regular audits of spice processing, polishing, and packaging units to detect and prevent intentional adulteration practices, including the use of lead chromate.
- Enhance awareness among farmers, processors, traders, and exporters regarding the serious health risks associated with lead contamination, as well as the potential economic losses arising from product recalls, rejection of export consignments, and damage to market reputation.
- Increase consumer awareness about the health impacts of dietary lead exposure and encourage the purchase of turmeric and spice products from reliable and certified sources.
- Undertake larger, multi-state studies incorporating analyses of soil, irrigation water, agricultural inputs, and processing practices to better understand the pathways and sources of lead contamination across the turmeric supply chain.
- Strengthen coordination among regulatory agencies, research institutions, and industry stakeholders to develop effective prevention strategies and ensure consistent enforcement of food safety regulations.

6. Annexure

6.1 Annex- I: Limits for Lead (Pb) in food commodities under the Food Safety and Standards Authority of India (FSSAI) regulations (FSSAI, 2004)

Article of food	Parts per Million by weight
Concentrated soft drinks (but not including concentrates used in the manufacture of soft drinks)	0.5
Fruit and vegetable juice (including tomato juice, but not including lime juice and lemon juice)	1
Concentrates used in the manufacture of soft drinks, lime juice and lemon juice	2
Baking powder	10
Edible oils and fats	0.5
Infant Milk substitute and Infant foods	0.2
Turmeric whole and powder	10
Anhydrous dextrose and dextrose monohydrate, edible oils & fats, refined white sugar (sulphated ash content not exceeding 0.03 per cent)	0.5
Ice-cream, iced lollies and similar frozen confections 1.0 Canned fish, canned meats, edible gelatin, meat extracts and hydrolysed protein, dried or dehydrated vegetables (other than onions)	5

All types of sugar, sugar syrup, invert sugar and direct consumption coloured sugars with sulphated ash content exceeding 1.0 per cent	5
Raw sugars except those sold for direct consumption or used for manufacturing purpose other than the manufacture of refined sugar	5
Edible molasses, caramel liquid and solid glucose and starch conversion products with a sulphated ash content exceeding 1.0 per cent	5
Cocoa powder on the dry fat free substance	5
Yeast and yeast products on the dry matter	5
Tea, dehydrated onions, dried herbs and spices flavours, alginic acid, on the dry alignates, agar, carrageen and similar products derived from seaweed matter	10
Liquid pectin, chemicals not otherwise specified, used as ingredients or in the preparation or processing of food	10
Food colouring other than caramel on the dry colouring matter	10
Solid pectin	50
Hard boiled sugar confectionery	2
Iron fortified common salt	2
Corned beef, luncheon meat, Cooked Ham, Chopped meat, Canned chicken, canned mutton and Goat meat and other related meat products	2.5
Brewed vinegar and Synthetic vinegar	
Foods not specified	2.5

6.2 Annex- II: Maximum level for lead across different food types and drinking water.

Food Type	Maximum Level (mg/kg or mg/L)	Regulatory Agency	References
Cereals and grains	0.02 mg/kg	FDA, EFSA	(FDA, 2025; (EFSA, 2023)
Vegetables	0.10 mg/kg	EFSA	
Fruits	0.10 mg/kg	EFSA	
Meat and offal	0.10 mg/kg	EFSA	
Fish and seafood	0.30 mg/kg	EFSA	
Milk and dairy products	0.02 mg/kg	EFSA	
Bottled water/drinking water	0.005 mg/L (5 ppb)	FDA	(FDA, 2022)
	0.01 mg/L	EPA, WHO	(USEPA, 2024; WHO, 2017)
Juice	0.05 mg/L (50 ppb)	FDA	(FDA, 2021)
Candy	0.1 mg/kg (100 ppb)	FDA	
Baby foods (fruits, vegetables, yogurts, dry cereals)	0.01 mg/kg (10 ppb)	FDA	(FDA, 2025)

6.3 Annex-III: Key regulations on Lead in India

Sector	India (Regulation / Standard)	Indian Limit
Household & Decorative Paints	Regulation of Lead Contents in Household and Decorative Paints Rules, 2016	≤ 90 ppm (dried paint film)
Toys	Toys (Quality Control) Order, 2020 (BIS certification mandatory)	≤ 100 ppm
Art Supplies	BIS Draft Standard (Poster Colours, 2024, under consultation)	Proposed ≤ 10 ppm
Primary Lead (Industrial)	Primary Lead (Quality Control) Order, 2025	Must conform to IS 27:2023
Food & Spices	FSSAI Contaminants, Toxins & Residues Regulations,2011	e.g., ≤2.5 ppm in turmeric powder
Drinking Water	BIS IS 10500:2012 – Drinking Water Standards	≤ 0.01 mg/L (10 µg/L)

6.4 Annex-IV: Screening & response levels of lead in different location (MoEf & CC,2015)

<table>
<tr><th rowspan="3">Hazardous Waste (levels Schedule II, HW Rules, 2008)</th><th colspan="5">Soil (Screening & Response Levels)</th></tr>
<tr><th rowspan="2">Response Levels (Dutch Interventio n levels)</th><th colspan="4">Screening levels (Soil quality guidelines for the protection of Environment & Human health)</th></tr>
<tr><th>Agricultural</th><th>Residential/ parkland</th><th>Commercial</th><th>Industrial</th></tr>
<tr><td>mg/kg (ppm)</td><td>mg/kg (ppm)</td><td>mg/kg (ppm)</td><td>mg/kg (ppm)</td><td>mg/kg (ppm)</td><td>mg/kg (ppm)</td></tr>
<tr><td>5000</td><td>530</td><td>70</td><td>140</td><td>260</td><td>600</td></tr>
</table>

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