CONTAMINATION OF FOOD CHAIN BY LEAD FROM BONE PROCESSING INDUSTRY IN INDIA

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Summary

Amaranth grown using the solid waste from a gelatine factory as manure in an experiment conducted by the Kerala Agricultural University had 1085 mg/kg of Pb, 200,000 times the b*enchmark dose level for developmental neurotoxicity. The sludge has since been approved and is being marketed as organic manure. This has serious implications for the food safety and public health at a national level.*

Introduction

Heavy metals like lead *(Pb) and cadmium (Cd), are sources of major public health hazard. Ridding the world of leaded petrol, which was responsible for some 90 per cent of human Pb exposure, has resulted in $2.4 trillion (4% of global GDP) in annual benefits, 1.2 million fewer premature deaths, higher overall intelligence and 58 million fewer crimes.[1] However, in developing countries, the exposures from paints, discarded batteries and E-wastes, tailings from mines and smelters etc., are increasing. More than half of the 15,000 children surveyed in six Indian cities had blood Pb level > 100 ug/l.[2] The estimated cost of lead poisoning among children in India is over Rs 3 billion per year.[3] The Indian* National Science Academy (INSA)[4] and the National Referral Centre for Lead Poisoning (NRCLP) are in the fore-front of the campaign for lead-free India.

Bone as a sink for environmental lead

A 1970 post-mortem study revealed that 95% of the human body burden of Pb was in bones.[5] Among the mammals, free-grazing cows and buffaloes will receive high doses from soil. In India, the skeletons of 525 million domestic animals[6] are a major sink for environmental Pb. The bone of the dead animals, about 2 million tpa is a major economic resource and also a source of Pb.

Nitta Gelatine India Limited

The mammalian bone contains about 22-27% collagen, a protein found in connective tissues. In India, about 200,000 tons of bone is used for extraction of 30,000 tpa of gelatine, hydrolysed collagen used in pharmaceutical preparations, photographic films and as food additives. Nitta Gelatine India Ltd (NGIL) Thrissur, Kerala - a

joint venture of the Nitta Gelatine Inc, Japan and the Kerala State Industrial Development Corporation, a 'red category', large scale unit[7] is one of the 11 producers in India.

Bone processing

With 152 tons of materials (crushed bone 127 t, HCl 5 t, CaOH 20 t) and 9,880 m^3 of river water, NGIL produces 22 t of ossein/gelatine and 42 t of dicalcium phosphate (DCP) daily. 40% of the 88 t of solid waste is discharged along with 9,230 m^3 of effluents into the Chalakudi River.[8] NGIL has been selling the sludge as "manure to all types of crops" for over a decade without the consent of the Kerala State Pollution Control Board (KSPCB).[9] In 2008 NGIL approached the Kerala Agricultural University (KAU) to "conduct studies on the application of manure on fruit bearing trees and *prove* that the fruits/crops do not cause any harmful effect and are safe to use."[10] Here, we review the NGIL-KAU study, reported in the Journal of Tropical Agriculture in August 2011[11] and its implication for food safety and public health.

NGIL-KAU Sludge research 2009-10

In two field experiments, bhindi (plot size 202.5 m^2) and amaranth (220 m^2) were cultivated during June-September of 2009 and November-March 2009-10 respectively. There were five sub-plots in the study- the control plot received the KAU's standard treatment and others received 25%, 50%, 75% and 100% substitution of farm yard manure (FYM) by the sludge. The main findings are: "Bhindi plants receiving 100% of manure through sludge showed earliness in flowering compared to other treatments" and "sludge application significantly increased the number of fruits/plant (p=0.05) and yield (p=0.01)". In amaranth, "lead (945 -1085 mg kg^{-1}), nickel (300 - 600 mg kg^{-1}), and cadmium (22 - 48 mg kg^{-1}) were detected regardless of the treatments". The researchers treat the finding of the metals in a casual manner.

The health effects of lead and cadmium

Pb and Cd are toxic elements and 'any dose is an overdose'. Pb can cause neurological disorders such as lack of muscular coordination, convulsions and coma. Lower levels have been associated with measurable changes in children's mental development and behaviour.[12] These include hyperactivity; deficits in fine motor function, hand-eye coordination, and reaction time; and lowered performance on intelligence tests. Effects among adults include increased blood pressure, decreased fertility, cataracts, nerve disorders, muscle and joint pain.[13] Since there are no placental or blood brain barriers, Pb gets into the foetus and the developing brain. Pb and Cd are also toxic to kidney. According to the International Agency for Research on Cancer (IARC), compounds of Cd[14] are confirmed human carcinogens, while Pb[15] is a probable carcinogen. At higher doses, Cd causes Itai-itai disease (lit. "it hurts-it hurts"), the symptoms and signs being weak and brittle bones, spinal and leg pain, a waddling gait, coughing, anaemia, and kidney failure. Known as one of the Four Big

Pollution Diseases of Japan, there have been 184 recognized and 388 potential Itai-Itai victims in the Toyama prefecture.[16]

Normal concentrations in foods

In a review of 94,126 studies of food and tap water done during 2003-09 in Europe by the European Food Safety Authority (EFSA), Pb concentrations in 65% of the samples was below the limit of detection (LOD). In 2,303 leafy vegetables, 44.4% were <LOD, median and maximum concentrations were 0.02 and 11.3 mg/kg respectively.[17] In 2180 milk and dairy drinks samples, 87% were <LOD and mean concentration ranged from 0.005 to 0.0117 mg/kg.[18] Milk from Indian cities had a mean lead concentration was 0.28 ppm.[19] The concentration of lead in KAU amaranth is 50,000 times higher than in EU vegetables and 4000 times higher than in Indian milk.

Tolerable intakes

The Panel on Contaminants in the Food Chain (CONTAM Panel) of the EFSA identified developmental neurotoxicity in young children and cardiovascular effects and nephrotoxicity in adults as the critical effects for the risk assessment for lead. The Benchmark dose level (BMDL) for developmental neurotoxicity is 12 µg/L of blood Pb and the corresponding dietary intake value is 0.5 µg/kg body weight per day.[20] Accordingly, a child weighing 10 kg may ingest 5 µg of Pb a day. One kg of KAU amaranth has tolerable lead level for 200,000 children. The cadmium level (max 48 mg/kg) is equally disturbing. Inabe et al determined the life time cadmium dose (LCD) at mild disease onset and severe disease onset for Itai-Itai disease at 3.1 and 3.8 g respectively.[21] A person who lives on a diet with Cd concentration as in KAU amaranth will absorb these LCDs in 65 and 79 days respectively.

Source of the heavy metals in amaranth

The authors have not provided data on the concentrations of heavy metals in the sludge or in the soil. The second author, who heads the radio-tracer laboratory of KAU, had analysed the sludge during the planning stage (Jan 2009) and at the end of the study (May 2010). Data from these analyses published elsewhere[22] are given in column 2 and 3 respectively of table 1. Columns 4 and 5 are from the paper under review and column 6 shows the maximum permissible concentrations of Pb, Ni and Cd in organic manure.[23]

Table 1 : Concentration of nutrients and heavy metals

Element and unit	1/4/2009 In Manure	14/05/2010 In Manure	2011 Paper In sludge	in Amaranth	Standards
1	2	3	4	5	6
N %	1.67	0.91	1.22	NR	
P %	4.29	3.66	4.2	NR	
K %	2.75	0.8	1.55	NR	
Pb mg/kg	25.36	2485	NR	945 – 1085	100
Ni mg/kg	ND	450	NR	300 - 600	50
Cd mg/kg	1.45	1.4	NR	22 – 48	5

ND = Not Detected
NR = Not Reported

The 2009 sample had normal values for nutrients and toxins, while the levels of Pb, Cd and Ni were high in the second sample. This anomaly has not been explained. Gelatine waste is a rich source of microbes and contamination has been reported in NGIL effluents and water from nearby wells.[24] Micro-organisms including pathogens were also isolated from gelatine factories in India[25] and Europe[26].

Conflict of interest

In the paper KAU is acknowledged as the source of funds. According to the information received under RTI, NGIL paid Rs 714,744 for this and two other studies. The university authorised the principal investigators to submit the results to the sponsor directly without any discussion or peer review.[27]

The observation in the test results of the May 2010 sample "the minimum requirements are not met wrt CN ratio and heavy metals" is not included in the paper published a year later. On 9th February 2010, the KSPCB certified that "the compost prepared from the ETP sludge" from NGIL "is found, as per the study report by the KAU to conform to specification for compost" and it can be "applied for all types of food and plantation crops."[28] Even though there has been no academic discussion, the KAU study and the NGIL's toxic waste have since travelled a long way.

Conclusions

The sponsored study with many loose ends and the certification of the toxic sludge from a 'red' category industry as manure escaped the attention of the organic farming community and the certifying agencies, the food safety regulators and the civil society. Here is a classic case of two national legislations which are on par with those in advanced countries, being flouted without detection and impunity. During its

operation for three decades, NGIL has dispersed an estimated 400,000 - 500,000 tons of solid waste in private and public lands. The 'Kerala model' may soon be used by the gelatine industry in India for profitably solving its 120,000 tpa solid waste crisis.

Because of its national implications for the food safety, public health and organic exports, this issue must receive the urgent attention of the authorities. Studies of concentrations of heavy metals, fluoride and micro-organisms in bones, DCP, gelatine, effluents and sludge from all gelatine and related units should be undertaken. If the levels are above the safe limits, documentation of the past disposal practices; mapping of contaminated areas and studies of concentrations of the toxins in soil, plants, food items, groundwater and blood of humans and domestic animals should be undertaken. Epidemiological studies among the exposed people should include assessment of IQ of children. Victims, if any, should be compensated.

Research in agriculture has wider implications in a globalized world. In NGIL-KAU collaboration, the scientists applied an unknown, undefined substance from a 'red' category industry in the soil of a seed production centre. They knew about the presence of mutagenic substances in it only after the end of the experiment. It appears that KAU and probably other agricultural research places in India do not have the mechanisms for safety evaluations and ethical considerations of researches, which are absolutely necessary, especially for the sponsored ones.

During the gelatine processing, the heavy metals trapped inside the mineral matrix of bone are transformed into leachable and bio-available form. This is a growing problem as the background levels of heavy metals in the soil are increasing. There is the problem of concentration also, for instance NGIL receives bones from about 1000 animals every day. The safety of bone for use in food and feed need be re-revisited as was done in the 1980’s with human nutrient supplement – bone meal-, and again during the BSE outbreak in Europe. Nowadays, animal bones from regions with BSE risks are burnt along with coal.

Review of NGIL-KAU study reminds us of the warning of Dioscerides in *Materia Medica two millennia ago that 'lead makes the mind give way'* and ignoring this warning by the 'business as usual' attitude can turn us into a nation of zombies.

Conflict of interest: None declared

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