Toxicokinetics and Toxicity

In this guide

Toxicokinetics

9. Inorganic borates readily hydrolyze to boric acid in the gut and uptake is almost exclusively (> 98%) as undissociated boric acid, which is likely absorbed by passive, non-mediated diffusion (Pahl et al., 2001). Once absorbed, it distributes evenly across body fluids and soft tissues in both humans and experimental animals, with a higher accumulation in bones (2-3 times higher than in soft tissues) (Forbes et al. 1954; Chapin et al. 1998). Boron crosses the placenta in humans and has been detected in placental and umbilical cord blood. Boron is not metabolized in the body. It is excreted largely unchanged in the urine, with renal clearance governing the excretion process (Murray, 1998).

Toxicity

10. The toxicity of boron has been reviewed by WHO (2009), ATSDR (2010), and Health Canada (2023). Boron toxicity primarily affects the reproductive and developmental systems, as demonstrated in both human and animal studies. In humans, lethal cases of boron ingestion have shown effects on the liver, kidneys, central nervous system, gastrointestinal system, and skin, with death primarily attributed to respiratory failure (ATSDR, 2010; Health Canada, 2023). The minimal lethal dose of ingested boron (as boric acid) was reported to be 2–3 g in infants, 5–6 g in children, and 15–20 g in adults (WHO, 2009).

11. Oral exposure animal studies have demonstrated that the reproductive system and the developing fetus are the most sensitive targets of boron toxicity. Adverse developmental effects have been identified for both acute and intermediate-duration exposures. Developmental toxicity observed in animal models, including decreased fetal weight, skeletal abnormalities (e.g., rib malformations), and visceral anomalies. High doses of boron caused significant reproductive effects in animals. Male rats showed histological alterations in the testes, sperm effects, disturbed spermatogenesis, and complete loss of viable sperm with prolonged exposure. Female rats experienced impaired ovulation and were unable to conceive when exposed to boron over 14 weeks (ATSDR, 2010; Health Canada, 2023). Further detail on the critical studies in animals is provided below.

12. Prolonged exposure has been linked to gastrointestinal and renal injury, while acute high intake (≥184 mg boron/kg/day) often leads to nausea and vomiting in humans. Although boron is not considered an essential nutrient for humans, low levels may confer some benefits to bone health and cognitive

function (ATSDR, 2010; Health Canada 2023).

13. This discussion paper examines the toxicity studies on boron by Heindel et al. (1992), Price et al. (1996) and Weir and Fisher (1972) which are used by authoritative bodies as the critical studies for their health-based guidance values. In addition, other toxicity studies showing effects at similar dose levels are summarised. The table presented in Annex A, summarises the findings of these different studies.