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Lithium accumulates in plasma and brains of fish after short-term exposure

Lithium production has increased dramatically during the past decade. A new study has found that exposure of rainbow trout to lithium results in fast accumulation in plasma and the brain, along with decreased concentrations of ions such as sodium.

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Source: Tkatcheva, V., Poirier, D., Chong-Kit, R., Furdui, V., Burr, C., Leger, R., Parmar, J., Switzer, T., Maedler, S., Reiner, E., Sherry, J. & Simmons, D. (2015). Lithium an emerging contaminant: Bioavailability, effects on protein expression, and homeostasis disruption in short-term exposure of rainbow trout. *Journal of Aquatic Toxicology*, Volume 161, April 2015, p.85-93

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The rising use of lithium (Li) in batteries, alloys and drugs will likely continue, not least thanks to lithium batteries used in electric cars.[1] Lithium is also known as a psychoactive drug, used since the 1950s as a mood stabiliser. Through environmental exposure, it has the potential to affect the physiology and body regulation of some species.

The 2006 EU Batteries Directive (2006/66/EC)[2] establishes rules for the production, placing on the market, recycling and disposal of batteries in order to avoid environmental contamination. Although it includes restrictions on the use of heavy metals (e.g. cadmium or mercury) in batteries or accumulators, it does not include any specific provisions on Li-based batteries.

The number of studies on the environmental monitoring and impact of Li in aquatic systems is limited, which the authors suggest is due to the lack of regulation of this element.

While its mechanism of action is not yet well understood, Li has been shown to affect the levels of arachidonic acid (AA), one of the most abundant fatty acids in the brain, potentially explaining its action as a mood stabiliser. Free fatty acids such as AA play a role in active cellular transport (the movement of ions or molecules across a cell membrane) via their impact on compounds that affect osmosis, leading the researchers in this study to look at ion composition and ion-transporting proteins which are involved in active transport.

The study looked at the effects of short-term exposure to Li on rainbow trout (*Onchorhyncus mykiss)*. The fish were exposed to a concentration of 1 mg Li per litre (l) for four days during three separate experiments. For comparison, ambient concentrations of Li in the world's major lakes range from 0.014–14 mg/l[3].

In each experiment, 80 juvenile trout were divided between two groups: half were exposed to Li and half were used as controls. At different time intervals over four days, 10 fish were selected and their brain and blood plasma sampled. Analyses measured the levels of plasma proteins and fatty acids, and the major ion concentrations in the brain and plasma samples.

The results showed Li to be highly bioavailable to fish. Lithium ions increased in the plasma after only eight hours, and in the brain after two days. After four days, the Li concentration in the brain had reached 44% of the plasma concentration, showing that Li had efficiently crossed the blood-brain barrier.

Meanwhile, several major ions such as sodium and calcium were depleted in plasma, and sodium, magnesium, potassium and ammonium in the brain, compared to control levels. This could severely impact the cellular function and body systems of the fish, with potential implications for survival. The authors suggest that the cause could be competition of the Li ions with sodium ions, leading to a disturbance of steady levels of sodium in cells, including those in the brain.

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1. http://ec.europa.eu/programmes/horizon2020/en/news/recharging-research-lithium-batteries

2. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006L0066-20131230&rid=1

3. Aral, H., and A. Vecchio-Sadus. 2008. Toxicity of lithium to humans and the environment—A literature review. *Ecotoxicology and Environmental Safety*. 70(3): 349–356

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In addition, levels of AA were elevated in plasma after two days, indicating that Li may interfere with the metabolism of free fatty acids. Several changes corresponding to Li exposure also occurred in plasma proteins.

To the authors' knowledge, this study is the first to report penetration of Li ions into the brains of fish following an environmentally relevant waterborne exposure, and shows that Li is highly bioavailable from water. The authors therefore identify the need for measurement of Li concentrations in surface, waste and drinking waters. Meanwhile, further studies are required to expand knowledge and understanding of the effects of Li on fish, as well as the potential effects of human exposure.

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