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Assignment 3

Toxic Tide: Addressing Policy Gaps in Battery Waste Management to Protect the Great Lakes Ecosystem

The environmental impact on the Great Lakes from emerging contaminants linked to battery waste is a growing concern. The rapid increase in e-waste streams, driven by accelerated consumption patterns and shorter device lifespans, is emerging as a pressing global environmental challenge in the near term (Leba et al., 2018), exemplified by the electromotive vehicle industry's projected 30 million sales by 2027 (Catsaros, 2024). Despite efforts to regulate and manage electronic waste, their effectiveness has been limited due to insufficient accountability and the low economic viability of recycling facilities (Shaikh et al., 2020). As a result, a significant portion of electronic waste ends up in landfills, where its toxic components are released into the environment (Shaikh et al., 2020).

As the main source of electricity for a broad range of devices, batteries are a significant contributor to total generated e-waste (Leba et al., 2018). The most used battery types contain considerable quantities of heavy metals like manganese, lead, cadmium, and lithium and other currently identified contaminants widely regarded with high ecotoxicity (Wang et al., 2014). Cadmium exposure occurs through the ingestion of contaminated food crops, leading to its accumulation in the human body, which can cause kidney diseases and has carcinogenic effects (Rarotra et al., 2020). Cobalt negatively impacts biomass and physiological activity in crops (Rarotra et al., 2020). Copper ingestion through contaminated food crops can result in liver damage, gastric-related issues, and neurological complications (Rarotra et al., 2020). Lead, often ingested via contaminated food, adversely affects the nervous system, kidneys, and other organs, and is associated with cardiovascular diseases and carcinogenic outcomes (Rarotra et al., 2020). Lithium disrupts the development of invertebrates, interferes with nucleic acid synthesis, and its accumulation in soil leads to severe phytotoxicity (Rarotra et al., 2020). Nickel induces high oxidative stress in mammalian and terrestrial plant systems and disrupts ion homeostasis (Rarotra et al., 2020).

Emerging contaminants include carbon-based nanomaterials such as single-walled carbon nanotubes (1 nm), graphene nanoplatelets (1–4 nm), multi-walled carbon nanotubes (10–20 nm), and other carbon nanotubes (2–50 nm), which alter soil microbial diversity, inhibit the growth of cyanobacteria and green algae, cause bioaccumulation in fish tissues, and lead to embryonic development issues and inflammatory responses(Lucia De Marchi et al., 2018). Ionic liquids exhibit antimicrobial activity, negatively affect plant growth and germination, bioaccumulate in aquatic ecosystems, and are highly toxic to algae (Rarotra et al., 2020). Metal and metal oxide nanomaterials, such as ZnO, Ag, and CuO nanoparticles (<50 nm), reduce photosynthetic rates, inhibit plant growth, modify soil microbial metabolism, and cause oxidative stress and cellular damage(Wang et al., 2014).Nevertheless, the leakage of emerging materials used in battery manufacture is still not thoroughly studied, and the elucidation of pollutive effects in environmental elements such as soil, groundwater, and atmosphere are an ongoing topic of interest for research (Wang et al., 2014).

Federal Laws in Canada for Battery Waste Management:

1. **Canadian Environmental Protection Act (CEPA), 1999**:
   CEPA governs hazardous waste management at the federal level, including batteries that are classified as hazardous waste due to their toxic components (e.g., lead, cadmium, mercury). It regulates the import, export, and transportation of hazardous wastes across provinces and internationally.

2. **Fisheries Act**:
   Batteries that leak into waterways may violate provisions of the Fisheries Act, which prohibits the release of harmful substances into fish-bearing waters.

3. **Reduction of Hazardous Substances (RoHS) Regulations**:
   Canada's RoHS standards aim to reduce hazardous materials like cadmium and mercury in products, including batteries, to minimize their environmental impact.

4. **National Model for E-waste Stewardship**:
   While not legally binding, this strategy encourages the development of a circular economy for electronic and battery waste, focusing on reuse, recycling, and extended producer responsibility (EPR).

Provincial Laws in Ontario for Battery Waste Management:

1. **Resource Recovery and Circular Economy Act (RRCEA), 2016**:
   This act mandates producer responsibility for waste, including single-use batteries. Producers are responsible for managing the lifecycle of their products, from collection and recycling to final disposal.

2. **Ontario Regulation 30/20 (Batteries)**:
   Under the RRCEA, this regulation specifically governs single-use and rechargeable battery waste. It requires producers to implement programs for the collection, reuse, and recycling of batteries weighing five kilograms or less.

3. **Environmental Protection Act (EPA), R.S.O. 1990**:
   The EPA regulates waste disposal in Ontario and prohibits improper disposal of hazardous waste, including batteries. It ensures batteries are processed at licensed facilities to prevent environmental contamination.

The management of emerging contaminants, such as those linked to battery waste, highlights significant gaps in policies designed to protect the Great Lakes ecosystem. While federal regulations like the Canadian Environmental Protection Act (CEPA) and Fisheries Act address the classification and containment of hazardous substances, they fall short in adequately monitoring and mitigating the release of emerging contaminants, including heavy metals (e.g. lithium) and advanced nanomaterials used in battery manufacturing. Similarly, Ontario's Resource Recovery and Circular Economy Act (RRCEA) and related regulations aim to promote producer responsibility and battery recycling only target small batteries and do not include EV's and products that use batteries. It faces challenges in enforcement and economic feasibility, leading to substantial leakage of toxic components into landfills and potentially into the Great Lakes. Advanced materials like carbon-based nanomaterials and metal oxide nanoparticles are even less regulated, despite their potential to alter microbial ecosystems and aquatic food webs. The lack of comprehensive studies on the environmental fate of these materials further exacerbates the issue, leaving critical gaps in our understanding of how soil, groundwater, and atmospheric elements are affected.

To address the environmental impact of emerging contaminants from battery waste on the Great Lakes, a unified regulatory framework led by the Canadian Council of Ministers of the Environment (CCME), with support from Environment and Climate Change Canada (ECCC) and provincial bodies like Ontario's MECP, is essential. Building on existing laws, this framework should include extended producer responsibility, mandatory recycling targets, deposit-return schemes, and strict bans on landfill disposal of batteries and products containing batteries.

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