

# A Review: Impact of Environmental Contaminants on Wildlife

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## Abstract

Environmental pollution is one of the most hazardous threats to wildlife populations throughout the world and affecting various taxa different habitats like terrestrial, aquatic etc. This review focus to current scientific evidence on the global scenario of environmental pollution and its impacts on wildlife, from recent systematic reviews. The various major pollutants can affects the wildlife including pesticides, drugs, plastics, heavy metals, organic pollutants and out coming contaminants like perfluoroalkyl and polyfluoroalkyl substances. This review explores the various processes through which pollutants can affects wildlife health. We analyse geographic and taxonomic patterns in pollution research, identifying critical knowledge gaps in under-studied regions and species. Furthermore, we focus the complex interactions between pollution and other global change drivers, specially climate change and biological invasions. The review concludes by evaluating current conservation strategies and proposing integrative approaches for mitigating pollution impacts on wildlife, emphasizing the need for standardized monitoring protocols, enhanced regulatory frameworks, and interdisciplinary collaboration within the worldwide health.

**Keywords:** Wildlife, Environmental pollution, Climate change, Anthropogenic.

## Introduction

The current geographical age is characterized by unexpected anthropogenic alterations to ecosystem of Earth which one of the most hazardous cause of environmental pollution and global changes (Chen et al., 2024). The agricultural activities, industrialization, urbanization, and associated human activities have released very large quantities of chemical contaminants into environment (Kumar, et. al., 2020), which create complex exposure for wildlife populations across aquatic and terrestrial ecosystems. These pollutants range from traditional contaminants like persistent organic pollutants (POPs) and heavy metals to emerging contaminants like micro-plastics, pharmaceuticals, and personal care products that shows specific impact for wildlife health and ecosystem.

The global scale of pollution impacts on wildlife is difficult to understand. The contaminants have been detected in organisms inhabiting even the most remote regions of the earth, from Arctic predators to deep-sea organisms, representing the capacity for long-range transport and environmental persistence of many pollutant groups (Brand et al., 2025). The wildlife organisms face chronic, often lifelong exposure to complex mixtures of contaminants, with effects manifesting at multiple levels of biological organization, from molecular and cellular disruptions to population declines and ecosystem level changes.

Understanding the global scenario of environmental pollution impacts on wildlife is critical for several reasons-

- Wildlife species serve as bio-indicators for ecosystem health and can provide early warnings of environmental contamination that may ultimately affect human populations (Chen et al., 2024).

- Pollution-induced declines in wildlife populations can have cascading effects on ecosystem structure and function, compromising essential ecosystem services.
- Biodiversity loss driven by pollution interacts work together with other global change drivers, potentially accelerating ecosystem degradation beyond critical thresholds.

This review aims to provide a comprehensive synthesis of current knowledge regarding the global impacts of environmental pollution on wildlife. We examine the major classes of pollutants affecting wildlife, the mechanisms through which they impart toxic effects, geographic and taxonomic patterns in exposure and effects, and interactions between pollution and other environmental stress. Finally, we measures existing conservation strategies and propose research and policy priorities for mitigating pollution impacts on wildlife in the context of global environmental change.

## Major Groups of Environmental Pollutants

### Heavy Metals and Metalloids

Heavy metals and metalloids shows most potent contaminants in wildlife toxicity with their bio-accumulation and toxic effects across different taxa. Heavy metals consist cadmium (Cd), mercury (Hg), lead (Pb), copper (Cu) and chromium (Cr) as well as metalloids like arsenic (As), are enters ecosystem through both natural and anthropogenic sources (Balali-Mood, et. al., 2021).

Cadmium observed in about 33 shorebird, which accumulated in liver and kidneys and associated with skeletal demineralization, infertility and renal toxicity (Ma et al., 2025). The mining activities, phosphate fertilizers and industrial emission are major source of cadmium pollution.

Methylated form (methylmercury) of mercury have hazardous impact on aquatic wildlife like fishes, due to its capacity for bioaccumulation and bio-magnification through aquatic food chains. Many investigations can represent the contamination of mercury in shorebird species (Ma et al., 2025). Methylmercury is an effective neurotoxicant that can affect motor function, reproduction, and survival in fish-eating birds and mammals.

Leads are significantly affects the wildlife, specially bird species. One of the most frequently documented lead pollution observed in tissue of shorebirds, with 28 studies reports (Ma et al., 2025). The major sources of lead exposure consist intake of lead shotgun pellets and fishing weights, as well as bio-accumulation from contaminated sediments and prey. Toxicity of lead in birds causes neurological and reproductive disorders.

In herbivorous marine animals like green turtles, dugongs and manatee the risk analysis of heavy metals such as copper, cadmium, zinc and chromium potentially affects the wildlife populations (Beneath the waves, 2025) . These metals accumulated in tissues of sea-grasses and transfer into animals through food webs and greatly affects lifespans.

### POPs (Persistent Organic Pollutants)

POPs are synthetic compounds characterized by long range transport, environmental persistence, toxicity, and bioaccumulation properties. POPs groups consist organochlorine pesticides, dioxins, PBDEs (polybrominated diphenyl ethers), PCBs (polychlorinated biphenyls), per- and polyfluoroalkyl substances (PFAS) (Guo, et. al., 2019).

- Organochlorine pesticides consisting DDT and its metabolites (DDE, DDD) that continue affect the wildlife decades after use restrictions. DDE is the persistent metabolite of DDT, which is a potent endocrine disruptor associated with eggshell thinning in birds fish-eating birds and raptors that leading populations decline crisis of the mid-20th century.
- Since 1970s-1980s PCBs banned in many countries but it is continue detected in tissues of wildlife world-wide due to their extreme persistence. In shorebirds, PCBs contamination has increased considerably, with laboratory experiments representing embryo-toxicity when combined with non-optimum temperatures (Ma et al., 2025). PCBs exposure associated with infertility, endocrine disorders, developmental abnormalities and immunosuppression. Due to bio-magnification the highest PCBs concentration present in marine mammals, predatory fishes and raptorial birds.
- PFAS substances related to contaminates, due to their high extreme environmental persistence, toxicity, and world-wide distribution. Recent studies reported that the PFAS accumulation in different taxa, consisting like little penguins, dolphins,

- and marine animals (Wells, et. al., 2024) and PFAS are related with infertility, hepatotoxicity, immunological disorders, and developmental abnormalities in wildlife.

## Agricultural Chemicals and Pesticides

The modern agricultural practices mainly based on chemical pesticides like herbicides, fungicides, and insecticides that can also affect non-target wildlife through bio-accumulation, food web and direct exposure effects which can increase widespread environmental contamination.

Due to nature of water solubility, persistence and effects on non-target organisms, the insecticides “neonicotinoid” is shows more toxic impact on birds, aquatic invertebrates, and other wildlife. The sublethal effects include decreased reproductive success, impaired navigation, and immunosuppression.

Diclofenac is anti-inflammatory drug, which is potent example of pharmaceutical contaminant that affect the wildlife. Widespread use of diclofenac in livestock, combined with vulture consumption of contaminated carcasses, lead to population declines exceeding 95% in three Gyps vulture species across the Indian subcontinent (Brand et al., 2025). This veterinary pharmaceutical caused visceral gout and renal failure in vultures, representing the potential for seemingly benign compounds to cause catastrophic wildlife population declines when exposure pathways and species sensitivities are not adequately considered.

## Plastics and Microplastics

Plastics are non-biodegradable pollutants has visible and pervasive threat to wildlife, with various impacts ranging from entanglement and ingestion of macroplastics to toxicity associated with microplastics and associated additive chemicals. Microplastics (<5 mm) and nanoplastics are ingested by a wide range of organisms, from zooplankton to marine mammals that may causes chemical toxicity (leaching of additives, concentration of ambient contaminants), physical impacts (gut obstruction, false satiation), and biological effects including oxidative stress, inflammation, and disruption of energy allocation (Yee, et. al., 2021).

A recent examining combined effects of microplastics and elevated temperatures on freshwater invertebrates found negative impacts on growth, reproduction, and stress responses. Filter feeders like *Daphnia magna*, were more affected than shredders and detritivores, representing species-specific sensitivities.

Among shorebird studies, only four investigated plastic debris or microplastics shows the significant knowledge gap given the prevalence of shorebirds in coastal environments where plastic accumulation is pronounced (Ma et al., 2025).

## Emerging Contaminants

Besides above numerous contaminates have significant risk to wildlife which include pharmaceutical drugs, personal care products, and industrial chemicals.

Through water effluents the pharmaceutical and personal products enter in environments by agricultural runoff, wastewater, and direct disposal, which reduced the biological activity of wildlife.

PAHs (Polycyclic aromatic hydrocarbons) are derived from oil spills, fossil fuel combustion, and industrial processes threatened risks to wildlife through both acute and chronic exposure. Oil contamination in shorebirds has been linked to reduce refueling and flight performance (Ma et al., 2025).

## Mechanisms of Pollution Impact on Wildlife Health

### Endocrine Dysfunctions

Environmental pollutants can affects the synthesis, secretion, transport, binding, action or elimination of hormones in wildlife that negatively affect the health, development, and reproduction.

In 2024, Chen et al. reported that effects of pollutants on endocrine functions that associated with wildlife health through thyroid hormone signaling, sex steroid pathways, adrenal function, and metabolic regulation.

The exposure of estrogenic compounds to aquatic environments associated with alteration of sex ratios and reproductive disorders. However, similar effects have been also reported in amphibians, reptiles, avies, and mammals.

The thyroid disorders by environmental pollutants like PCBs, PBDEs, and perchlorate, can affect development, metabolism, and thermoregulation. In avies and mammals, the thyroid disorders during critical developmental leads to produce permanent neurological and behavioural changes.

### **Infertility**

Pollutants can directly affect the wildlife populations through reproductive disorders that occurs through mechanisms like endocrine disorders, change reproductive behaviour, gonadal toxicity and decrease the offspring survival.

Metal pollution also reproductive success in wild bird populations. Concentrations of metals in feathers of blue tits (*Cyanistes caeruleus*) and feat great tits (*Parus major*) are negatively correlated with reproductive success (Brand et al., 2025). Similarly, exposure to the insecticide imidacloprid reduced reproduction in female orchard mason bees (*Osmia lignaria*).

### **Immunological effects**

The pollutants exposure increases the infectious diseases and reduced biological activity in wildlife, due to immune-toxicity. Chen *et al.* (2024) reported that the role of pollutants in contributing to complex disease dynamics through effects on immune function.

The effects of pollutants reduced production of immunoglobulins, proliferation of lymphocytes, reduced phagocytic functions and change the cytokine signalling. Thus, reduced immunity in wildlife increase the infections, and mortality.

### **Ethological effects**

Brand et al. (2025) reported that various independent groups of pollutants can change behavioural characters like activity and exploration, boldness, sociability, and aggressiveness. These behavioural changes can affect the foraging success, predator avoidance, and social interactions.

### **Neurological effects**

Environmental pollutions can reduced wildlife fitness through neurological effects by sensory, motor, behavioural, and cognition functions.

Heavy metals like mercury and lead are effective neurotoxicants. The exposure of lead in birds leads to reduced biological activity, and neurological disorders. The exposure of methylmercury in fish-eating birds and mammals can reduced motor coordination, visual function, and cognitive performance and also affect foraging efficiency.

### **Oxidative Stress**

Various environmental pollutants can induce oxidative stress through reactive oxygen species (ROS) and changes of antioxidant defenses. Oxidative stress can damage proteins, nucleic acids (DNA), and lipids involving in diverse pathological disorders like tissue damage, inflammation, and accelerated aging.

### **DNA damage**

It induced by genotoxic pollutants like polycyclic aromatic hydrocarbons, some metals, some pesticides etc. can have long-term effects on individual health and population genetic diversity with potential to the carcinogenic activity and heritable genetic damage.

## Conclusions

The environmental pollution represents a vast and persistent threat to wildlife populations worldwide with effects reported across various taxa and ecosystems. Pollutants like heavy metals, pesticides, pharmaceuticals, persistent organic pollutants, and emerging contaminants accumulate in wildlife tissues, endocrine disorders, immune disorders, reproduction, nervous system function, and cellular processes. These effects can reduce individual fitness and population viability, contributing to biodiversity loss and ecosystem degradation.

The emerging contaminants like PFAS, pharmaceuticals, and microplastics, require particular research attention given their increasing environmental prevalence and potential for biological effects.

Effective conservation requires integrated approaches that address pollution within the broader context of planetary health. Standardized monitoring protocols, improved data sharing, New Approach Methods, and international collaboration can advance understanding of global pollution impacts. Regulatory frameworks must evolve to account for cumulative risks of multiple stressors and protect vulnerable species not adequately represented in current guidelines. By integrating pollution control with climate action, biodiversity conservation, and sustainable development goals, it may be possible to mitigate the impacts of environmental pollution on wildlife and preserve ecosystem integrity for future generations.

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