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Potential Economic Losses From Microplastics in the Livestock Sector: A Study on Selected Animals

Adi Sutanto[1] | Iswahyudi Iswahyudi[2,3] | Imbang Dwi Rahayu[1] | Asmah Hidayati[1] | Marchel Putra Garfansa[2,3] | Yusnita Wahyuni Silitonga[4] | Rafiqah Amanda Lubis[4] | Mukhlis Mukhlis[4] | Muhammad Nizar Hanafiah Nasution[5] | Dodi Sukma R. A.[6]

[1]Department of Agriculture and Animal Science, University of Muhammadiyah Malang, Malang, East Java, Indonesia | [2]Department of Agrotechnology, Universitas Islam Madura, Pamekasan, East Java, Indonesia | [3]Center for Environmental Agriculture Management, Universitas Islam Madura, Pamekasan, East Java, Indonesia | [4]Department of Agrotechnology, Universitas Muhammadiyah Tapanuli Selatan, Padang Sidempuan, North Sumatra, Indonesia | [5]Department of Agrotechnology, Universitas Graha Nusantara, Padang Sidempuan, North Sumatra, Indonesia | [6]Department of Forestry, Universitas Lancang Kuning, Pekanbaru, Riau, Indonesia

Correspondence: Adi Sutanto (sutanto@umm.ac.id)

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ABSTRACT

Economic losses in the livestock sector have been done, but how much economic loss is caused by exposure to microplastics in certain animals has never been done. This study aims to analyze the impact of microplastics on economic losses in laboratory animals (mice) and poultry (ducks). The method used was in the form of secondary data analysis on the rate of animal mortality due to exposure to various types of microplastics. The data are used to simulate the amount of production, annual population, and potential economic losses per cycle and per year. Economic value is determined based on the latest prices, and minimum prices. The results showed that exposure to microplastics in animals led to 20% to 80% deaths, with potential annual losses reaching USD 113,568 in rat farmers, while in ducks, polytetrafluoroethylene (PTFE) exposure led to embryo death by 35% and annual losses of up to USD 6,859,091.14. These findings suggest that the economic impact of microplastics has the potential to outweigh losses due to conventional biological threats such as infectious diseases. The study concluded that microplastics can be a significant factor in reducing productivity and causing large economic losses in the livestock sector. The impact of these findings is crucial in driving the need for regulations and mitigation strategies to control microplastic exposure in the farm environment.

1 | Introduction

Analysis of economic losses on livestock has an important role in increasing public knowledge, especially in understanding the extent to which certain factors can affect the sustainability of the livestock sector (Sutanto et al. 2024). Livestock farming is an important part of food security, especially in developing countries. Research shows that livestock production activities improve livelihoods and contribute to food security by providing essential nutrients (Idamokoro 2023). Losses in livestock directly threaten food availability and quality. With quantitative data and information on potential losses due to disease, environmental pollution, or new threats such as microplastics, the public—including farmers, consumers, and policymakers—can get a more accurate picture of the risks faced in livestock production systems (Kotykova et al. 2024; Nuvey et al. 2020). This research also serves as an educational medium to raise awareness that disturbances in animal health not only have an impact on production yields, but also on real and significant economic losses (Ngom et al. 2024). Furthermore, this understanding can encourage the community to support the implementation of more sustainable and safe farming practices, as well as encourage governments to establish evidence-based regulations to minimize adverse economic impacts in the long term.

Previous studies on the analysis of economic losses on livestock have generally focused on the impacts of infectious diseases, climate change, and other biological disturbances. Economic losses in livestock farming, such as those due to foot-and-mouth disease (FMD), can have significant financial implications, with annual total economic losses due to FMD in India ranging from Rs 12,000 to 14,000 crore (Singh et al. 2013). Brucellosis in India results in a median loss of 3.4 billion USD annually (Singh et al. 2015), while heat stress in the US livestock industry incurs losses averaging 2.4 billion USD annually (St-Pierre et al. 2003). The largest economic losses in Ukraine's livestock production sector in 2022 were concentrated in regions directly impacted by military actions, with total economic damages from livestock production losses amounting to over 785.6 million euros based on regional prices and 800.9 million euros based on national prices (Kotykova et al. 2024). However, most of these studies have not explored environmental pollution factors such as microplastics as causes of economic losses, thus opening new space for a more comprehensive study of non-biological threats that have the potential to affect the productivity and sustainability of the livestock sector.

> *"Previous studies on the analysis of economic losses in livestock have been largely limited to traditional factors such as infectious diseases, heat stress, and parasites, with a primary focus on large farm animals such as cattle, goats, and commercial poultry."*

Previous studies on the analysis of economic losses in livestock have been largely limited to traditional factors such as infectious diseases, heat stress, and parasites, with a primary focus on large farm animals such as cattle, goats, and commercial poultry. The approach used is often only descriptive or uses loss estimates based on general assumptions without considering emerging environmental pollution factors such as microplastics (Zhao and You 2022). In addition, some studies are still minimal in the use of detailed quantitative data and based on simulations of actual production and long-term projections (Kephe et al. 2021; White et al. 2011). Studies also tend to focus on physical losses and loss of outcomes, without directly linking them to contemporary environmental impacts that are increasingly apparent (Ekins and Zenghelis 2021). In fact, microplastics as new pollutants have now been proven to accumulate in the animal's body and cause biological disorders that lead to decreased productivity and even death (Chen et al. 2022). Unfortunately, until now there has not been much study that specifically analyzes the economic losses on livestock caused by exposure to microplastics, so this topic is an important gap that needs to be studied immediately to support the economic resilience of livestock in the modern era.

The aims of this study was to analyze the impact of microplastic exposure on mortality rates and productivity declines in certain animals (such as white rats and duck embryos), and to calculate the magnitude of potential economic losses caused by these impacts based on current production and price data. The novelty of this study analyzes the quantitative economic losses on two types of livestock, namely ducks as consumption poultry and white rats, which are commercially cultivated for research and biomedical needs. Laboratory rats in this context are treated as part of the livestock sector because they have a clear system of maintenance, production, and economic value in the research industry. This study is an initial approach to examining the potential economic losses due to microplastics from the perspective of livestock productivity and mortality. The significance of this research lies in its contribution to broadening understanding of the impact of nontraditional, particularly microplastic pollution, on economic sustainability in the livestock sector. By providing quantitative data on measurable losses, this research provides a scientific basis for policymaking, encourages efforts to mitigate environmental risks, and raises awareness of the importance of controlling microplastic pollution to maintain the productivity and economic benefits of farmers in the future.

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2 | Materials and Methods

2.1 | Data Collection

The secondary data obtained provided information about the survival rate of white rats and ducks, which was then used as input in the numerical simulation process. To evaluate the reliability of the impact of microplastics on the potential economic losses experienced by farmers, experimental data on mortality rates and decreased production performance due to exposure to microplastics in experimental animals such as rats were studied from various sources, including Garfansa, Setyobudi, et al. (2024), Li, Rong, et al. (2025), and Ma et al. (2024). In addition, data on the impact of microplastics on poultry, especially ducks, were also reviewed from research results such as Campos et al. (2025), who reported changes in egg hatching failure due to exposure to microplastics. This comprehensive review of the experimental data aims to strengthen the credibility and accuracy of the estimated economic losses calculated, both per production cycle and per year, in the context of laboratory rat and duck farming agribusiness.

> *"The selection of laboratory white rats and ducks as representative animals in this study was based on the availability of adequate experimental data on microplastic exposure, as well as the economic relevance of both in the livestock system."*

The selection of laboratory white rats and ducks as representative animals in this study was based on the availability of adequate experimental data on microplastic exposure, as well as the economic relevance of both in the livestock system. White rats are model animals that are widely used in biomedical and toxicological research, and are massively produced by laboratory animal breeding units, making them part of the research-based livestock sector. Exposure to microplastics in mice may represent a risk to small animals in a closed maintenance system. Meanwhile, ducks are widely cultivated poultry, especially in the Southeast and South Asian regions, and are particularly susceptible to microplastic contamination from the aquatic environment. Data on economic losses due to microplastics in ducks reflect the potential impact on the poultry sector that depends on water quality and natural feed. The results of these two species were used as an initial model to construct a framework for quantitative analysis of potential economic losses in the broader livestock sector, assuming that similar toxic effects and production losses could occur in other species that are systemically exposed to microplastics.

2.2 | Calculation of Economic Losses

In calculating economic losses due to microplastic exposure, several basic assumptions are used to maintain the consistency of estimates: (1) the mortality threshold is based on the percentage of deaths reported in each of the studies analyzed, without making any reductions or corrections, given that the data are sourced from controlled experiments; (2) animal prices and production values per cycle refer to livestock literature (Dawan and Darana 2015; Kartika et al. 2013); and (3) to calculate the value of annual economic losses, we use the conversion of currency exchange rates to USD with the reference rate for 2025 in April 2025 (1 USD = IDR 16,484). These assumptions help to maintain the model's comparability as well as represent the reality of the global market in general.

The calculation of economic losses is derived from the mortality rates due to microplastic exposure reported in various toxicological studies that are converted through the following steps: (1) multiplying the percentage of deaths by the number of animal populations per production cycle and per year, to obtain the number of individuals lost; (2) multiplying the number of missing individuals by the value of income per individual per cycle; and (3) accumulating the value of losses per cycle and per year to obtain an estimate of the total economic losses due to microplastics based on Dawan and Darana (2015) and Kartika et al. (2013). To consider the variability of market prices, a simple sensitivity analysis was carried out using the lowest price based on the determination of the minimum support price (MSP). The MSP value is calculated by considering the present value and is a reference in estimating economic losses, both based on the loss of production yield and the increase in livestock mortality due to exposure to microplastics per year. Equation (1), proposed by Oliveira et al. (2014) and Sutanto et al. (2024), was applied to each state in order to get the results:

$$EL = NEP \times \left(\frac{\% \, YL}{100} \right) \times MSP \quad (1)$$

where EL is the economic losses due to MPs (USD), NEP is the normal production estimation (animals), %YL is the percentage yield losses due to MPs, and MSP is the minimum support price (USD). This is done to evaluate the range of potential losses that may occur under different market conditions, thereby strengthening the interpretation of the results.

3 | Result and Discussion

3.1 | Actual Animal Losses Due to MPs

Exhibit 1 presents data from several previous studies showing the impact of microplastics on animal mortality rates (white rats and ducks). The types of polymers used include polyethylene terephthalate (PET), polystyrene (PS), and polytetrafluoroethylene (PTFE). Particle sizes vary from 0.5 μm to not specified, with concentrations ranging from 20 μg to 5 mg/mL. A study by Garfansa, Setyobudi, et al. (2024) showed that exposure to PET in mice at a dose of 600 μg led to mortality by 34.4%. Meanwhile, Li, Rong, et al. (2025) reported that exposure to 20 μg of PS caused 20% mortality. In another study by Ma et al. (2024), PS with a particle size of 0.5 μm at a concentration of 2 mg/mL showed a much higher mortality effect, that is, 80%, indicating that the particle size and concentration play an important role in its toxicity. In addition to mice, the impact of microplastics was also recorded in duck embryos, where exposure to PTFE of 5 mg/mL led to 35% mortality, according to Campos et al. (2025). Overall, this table shows that exposure to microplastics of certain types and concentrations contributes significantly to the increase in mortality in animals, so it can be an important reference in assessing the potential economic losses on farms affected by microplastic contamination.

In previous toxicology studies, there has been reported a relationship between the dose of microplastic exposure and certain biological impacts in animals, such as weight loss, reproductive disorders, oxidative stress, and histopathological changes in the digestive organs and liver. Research by Chang et al. (2024) showed that exposure to microplastic PS in a concentration of 100 mg/day of body weight per day significantly reduced growth rates and feed intake in model animals. Similarly, a study by Campos et al. (2025) reported that microplastic exposure thresholds above 50 μg/L in drinking water correlated with increased poultry embryo mortality. These effects directly affect productivity, such as reduced feed conversion efficiency, increased mortality rates, and disruption of the reproductive cycle, which ultimately impacts economic losses in the context of farming. Nevertheless, it should be recognized that the exact dose-response relationship in commercial livestock species is still rarely directly studied and requires further studies with more applicative designs.

Microplastics have the potential to cause death in animals because these particles can cause various toxicological impacts both physically and chemically (Jeong et al. 2024). Physically, ingested microplastics can disrupt the digestive tract, cause blockages, intestinal irritation, and reduce nutrient absorption, resulting in a drastic decrease in physiological conditions (Fröhlich 2024). In addition, microplastics can also cause false satiety, which causes animals to eat less and experience energy deficiencies and malnutrition (Setyono et al. 2024).

Chemically, microplastics often contain or absorb harmful chemicals such as heavy metals, pesticides, and industrial additive compounds (e.g., bisphenol A and phthalates) (Temel 2025).

EXHIBIT 1 | Potential effect of MPs on animal mortality.

Animal	Polymer type	Size	Concentration	Death	Reference
Mice	Polyethylene terephthalate (PET)	—	600 µg	34.4%	(Garfansa, Setyobudi, et al. 2024)
Mice	Polystyrene (PS)	—	20 µg	20%	(Li, Rong, et al. 2025)
Mice	PS	0.5 µm	2 mg/mL	80%	(Ma et al. 2024)
Duck embryo	Polytetra-fluoroethylene (PTFE)	—	5 mg/mL	35%	(Campos et al. 2025)

When they enter the animal's body, these substances can cause oxidative stress, tissue inflammation, organ damage (especially the liver, kidneys, and reproductive system), as well as hormonal disorders (Nahiduzzaman et al. 2025). This effect is more dangerous when exposure occurs over the long term or at high concentrations (Bhowmik et al. 2024; Lang et al. 2024). The studies listed in Exhibit 1 show that even at relatively low concentrations, certain types of microplastics, such as PS and PTFE, have been shown to significantly increase mortality in mice. Therefore, exposure to microplastics poses a serious threat to animal health and survival, both in the context of ecosystems and livestock systems (Su et al. 2025).

3.2 | Economic Losses Due to MPs

Exhibit 2 contains the potential economic losses caused by exposure to microplastics in farm animals, namely laboratory white mice and duck embryos. The calculations in this table include the percentage of loss due to death, production per cycle, population per year, income per cycle and per year, as well as the estimated economic loss in the two time scales. For laboratory white mice, exposure to PET microplastics with a loss rate of 34.40% resulted in economic losses of USD 225.39 per cycle and USD 48,834.24 per year, out of a total production of 360 heads per cycle and an annual population of 78,000 heads. Normal earnings without exposure reached USD 655.20 per cycle and USD 141,960 per year.

Exposure to PS microplastics shows two different levels of loss depending on the concentration or size of the particles. At a loss of 20%, the value of economic losses is USD 131.04 per cycle and USD 28,392 per year. However, when the loss rate increases to 80%, losses jump sharply to USD 524.16 per cycle and USD 113,568 per year, signaling that the high mortality rate has a significant economic impact. Meanwhile, in duck embryos exposed to PTFE with a loss rate of 35%, the calculated economic losses reached USD 3,516.98 per cycle and USD 6,859,091.14 per year. With a total annual population of 43,549,785 and a production per cycle of 22,330 heads, the normal income that can be generated is USD 10,048.5 per cycle and USD 19,597,403.3 per year. Overall, the table shows that exposure to microplastics has the potential to cause very significant economic losses to the livestock sector, depending on the type of polymer, mortality rate, scale of production, and number of livestock populations.

Exposure to microplastics (MPs) can cause significant economic losses, both in laboratory animals such as mice and in poultry such as duck embryos. These losses arise from the increasing mortality rate due to microplastic toxicity, which directly decreases production output and farmers' income (Sutanto et al. 2024). These findings are in line with studies by Chen et al. (2023), which stated that long-term exposure to microplastics can decrease livestock productivity through sublethal effects such as indigestion, oxidative stress, and impaired organ function. In fact, PS-type microplastics can cause weight loss and reproductive disorders in mice, which on an industrial scale can result in population stock imbalances and lower production cost efficiency (Souza et al. 2023). Meanwhile, in poultry, estimated that economic losses to the poultry industry due to infectious bronchitis virus (IBV) only reached 3567.4 USD/year (Colvero et al. 2015), so the impact of microplastics has the potential to exceed traditional biological threats.

3.3 | Comparison of Economic Losses by MPs and Other Factors

Exhibit 3 shows a comparison of the economic losses caused by microplastics with several other causative factors in the livestock industry. Based on data from this study, economic losses due to exposure to microplastics in animals such as mice and ducks range from USD 28,392 to USD 6,859,091.14. This value reflects the potential for large losses that were previously not widely considered in the livestock economy. For comparison, foot and mouth disease in livestock such as cattle, buffaloes, goats, sheep, and pigs was reported by Singh et al. (2013) to cause losses of USD 140.46 to USD 163.87, while in cattle specifically, according to Rasmussen et al. (2024), the losses reached USD 2300. This suggests that microplastics can cause much higher economic losses than certain infectious diseases, especially if they occur widely in livestock systems.

Even greater losses were found in heat stress cases affecting various types of livestock such as cattle, pigs, broiler chickens, and turkeys, with a huge loss value of USD 2.4 billion per year (St-Pierre et al. 2003). Meanwhile, parasitic infections in livestock such as cattle, camels, buffaloes, goats, and sheep are reported to cause losses of up to USD 8.2 million per year (Khaniki et al. 2013). From this comparison it can be concluded that although microplastics are a relatively new threat, their potential economic losses cannot be ignored and may even exceed some traditional

EXHIBIT 2 | Impact of MPs on economic losses to animals. MPs, microplastics.

Animal	Polymer type	Losses (%)[a]	Production-/cycle[b]	Population-/year[c]	Income/cycle (USD)	Income-/year (USD)	Economic losses /cycle (USD)[d]	Economic losses /year (USD)[d]
Mice	Polyethylene terephthalate (PET)	34.40%	360 animals	78,000	655.2	141,960	225.3888	48,834.24
Mice	Polystyrene (PS)	20%	360 animals	78,000	655.2	141,960	131.04	28,392
Mice	PS	80%	360 animals	78,000	655.2	141,960	524.16	113,568
Duck embryo	Polytetrafluoroethylene (PTFE)	35%	223,30 birds	43,549,785	10,048.5	19,597,403.3	3516.975	6,859,091.14

[a]Percentage of losses caused by MPs based on Exhibit 1.
[b,c]*Production and population* (*Source:* Dawan and Darana (2015), Kartika et al. (2013), Sari (2024), El-Hack et al. (2019), and BPS (2025)).
[d]Based on the average price paid to the farmer per animal or bird (*Sources:* Dawan and Darana (2015); Kartika et al. 2013).

biological threats. Therefore, the issue of microplastics needs to receive serious attention in future livestock policies and research.

3.4 | Sources and Exposures of Microplastics in Animals

The local context plays an important role in determining the pathways of exposure and the extent of the impact of microplastics on the livestock sector (Su et al. 2025). Climate variability, regional pollution levels, and different waste management practices between regions can significantly affect the concentration of microplastics entering the livestock feed and drinking water chain (Basumatary et al. 2025). For example, in areas with high rainfall, surface runoff can carry plastic particles from farmland or settlements to livestock water sources (Li, Liu, et al. 2025). On the other hand, areas with high levels of industrial pollution or inadequate waste management systems have the potential to have greater accumulation of microplastics in soil and water (Shini et al. 2025). In addition, local farming practices such as the use of recycled organic waste as feed or fertilizer can also be an entry point for microplastics into farm systems (Iswahyudi et al. 2024). Therefore, microplastic risk assessment needs to consider local ecological and socioeconomic conditions so that the designed interventions are contextual, targeted, and practically effective (Alam and Rahman 2025; Munhoz et al. 2023).

In animals, exposure to microplastics can occur through a variety of pathways, both directly and indirectly (**Exhibit 4**). The main sources of microplastics for animals include contamination of feed, drinking water, air, and degraded cage equipment (Khan et al. 2024). In livestock systems, animal feed can be contaminated by microplastics due to unhygienic production, packaging, or storage processes (Bahrani et al. 2024). A study by Yashwanth et al. (2025) found the content of microplastics in poultry feed derived from plastic additives and cross-contamination during distribution. In addition, drinking water used in farms can also contain microplastics, especially if it comes from surface sources that are exposed to household or industrial waste (Singh 2024).

Exposure to microplastics in animals occurs primarily through accidental exposure that may occur due to air polluted with plastic particles, or the use of thermally degraded plastic bottles and containers (Zhang et al. 2024). Types of polymers commonly found as contaminants include PET, PS, and polyethylene (PE) (Gündoğdu et al. 2024). These particles vary in size from a few micrometers to millimeters, allowing them to be accidentally ingested by animals during eating or drinking activities (Dong et al. 2023). Once inside the animal's body, microplastics can interact with internal tissues and organs, causing oxidative stress, immunological disorders, and, in some cases, leading to death (Garfansa, Setyobudi, et al. 2024).

With the increasing prevalence of microplastics in the environment, the risk of exposure to livestock is a serious issue that needs to be considered (Prata et al. 2021). Not only does it have an impact on animal health, but it also has the potential to cause significant economic losses due to premature death, decreased productivity, and increased health impact control costs (Campos et al. 2025). Therefore, identifying exposure pathways and controlling sources of contamination is a crucial first step in efforts to mitigate the

EXHIBIT 3 | Comparison of economic losses affected by MPs and other factors.

Animal	Case	Economic losses (USD)	Reference
Mice and duck embryo	MPs	28,392–6,859,091.14	Present study
Cattle, buffalo, sheep, goat, and pig	Foot and mouth disease	140.46–163.87	(Singh et al. 2013)
Cow	Foot and mouth disease	2300	(Rasmussen et al. 2024)
Cows, cattle, sows, hogs, broilers, layers, and turkeys	Heat stress	2.4 billion	(St-Pierre et al. 2003)
Cattle, camel, buffalo, sheep, and goat	Parasitic infections	8.2 million	(Khaniki et al. 2013)

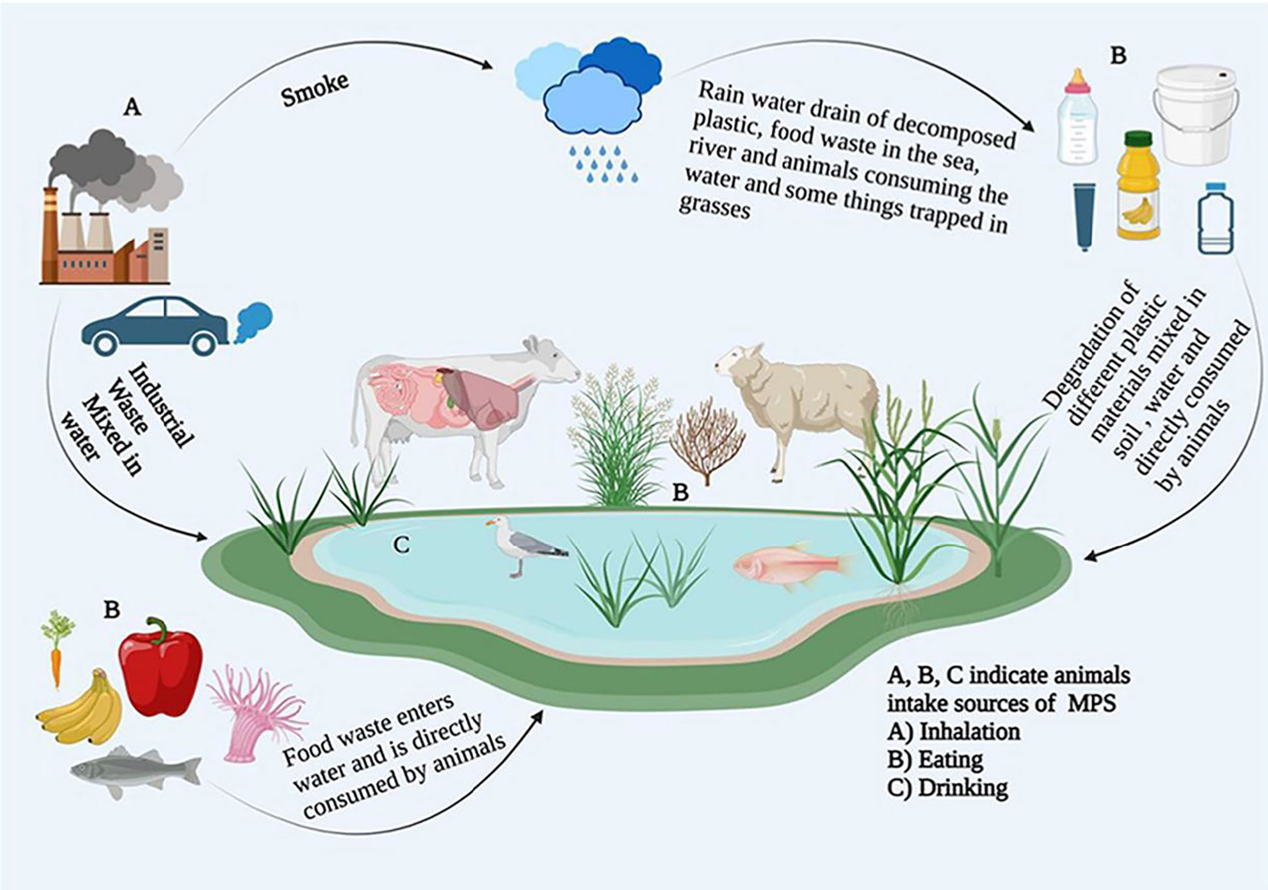

EXHIBIT 4 | Pathway of microplastic intake by animals (Khan et al. 2024). [Color figures can be viewed at wileyonlinelibrary.com.]

risk of microplastics in the livestock and animal research sectors (Pause et al. 2024).

3.5 | Policy Implications and Risk Management

The impact of microplastics on animals, both farm animals and laboratory animals, is not only a health issue, but also has serious implications for economic losses. Therefore, comprehensive risk management policies and strategies are needed to reduce exposure to microplastics in animals and minimize their impact (**Exhibit 5**). One of the most important first steps is to strictly monitor feed and water quality. Regular checks of feed and water to ensure they are free of microplastic contamination should be standard procedure in farm and laboratory practices (Siddique et al. 2025). In addition, feed producers and drinking water providers for livestock must also be given legal responsibility to ensure the safety of their products from pollutants such as microplastics (Agbasi et al. 2025; Usman et al. 2022).

Microplastic mitigation strategies in the farm environment include more responsible management of plastic waste, the use of nonplastic materials or environmentally friendly plastics for cage equipment, and education of farmers about the dangers of microplastics (Moshood et al. 2021; Usman et al. 2020). The development of water filtration technology, adjustment of feed formulations, and the reduction of single-use plastics in farm areas are also important parts of this mitigation strategy (Garfansa, Zalizar, et al. 2024). The implementation of a risk-based environmental management system in each farm unit can

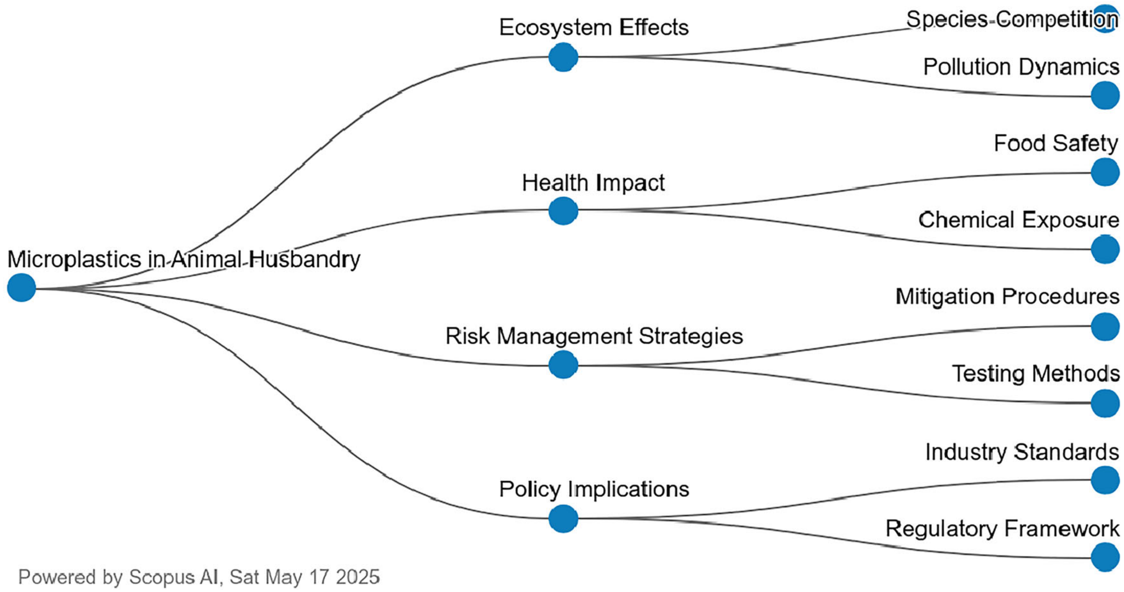

EXHIBIT 5 | Concept map of policy implications and risk management of microplastics in animal husbandry. [Color figures can be viewed at wileyonlinelibrary.com.]

help detect and address sources of microplastic exposure early (Pires and Sobral 2021; Senathirajah and Palanisami 2023).

The government plays an important role in controlling the economic impact of microplastics through strict regulations and adequate policy support (Sutanto et al. 2024). Regulations that regulate the maximum limit of microplastic content in animal feed, water, and air need to be developed and implemented nationally (Costa et al. 2020; Deme et al. 2022). In addition, support for research and technological innovation to detect and reduce microplastics in the livestock sector should be increased. The government can also provide incentives for business actors who implement environmentally friendly and microplastic-free farming practices (Munhoz et al. 2023). With the synergy between quality control, technical mitigation strategies, and the active role of the government, microplastic risk control in the livestock sector can be carried out effectively and sustainably.

Mitigation strategies against microplastic exposure in the livestock sector can be strengthened by reviewing real-world examples of policies that have been implemented in several countries (Munhoz et al. 2023). The European Union, through the Regulation on the registration, evaluation, authorization, and restriction of chemicals (REACH), has tightened the use of microplastic materials in agricultural and feed products, including banning the use of feed packaging made of single-use plastics in several member states such as Germany and the Netherlands (EC 2020). This policy evaluation showed a decrease in the level of microplastics in the feed production system by 30%–40% within 2 years (Giri et al. 2024). In Japan, some medium-scale farms have implemented ultrafiltration membrane-based water filtration systems to prevent microplastic particles from entering livestock drinking systems, with the result of a reduction in plastic particles by more than 90% in monitoring tests (Lackner and Branka 2024). These examples show that the right technological and policy approaches can be applied practically and have a significant impact on reducing microplastic exposure in the farm environment.

3.6 | Study Limitations

The study used secondary data from laboratory experiments conducted in a controlled environment, especially on model animals such as mice and duck embryos. This approach allows for an early estimate of the potential impact of microplastics on animal health and mortality rates, which is further used to estimate economic losses. However, extrapolating laboratory results to the scale of commercial farms faces several limitations. One of the main challenges is ecological validity, that is, the extent to which results from the laboratory environment can reflect real conditions on the farm, such as variability of environmental factors, chronic exposure, feed types, farm management systems, and the specific biological resilience of each livestock species.

The physiological response of animals in the laboratory can also differ significantly from that of farm animals in the field exposed to microplastics over long periods of time and in more complex environmental contexts. Therefore, while these findings provide an important preliminary picture, the results need to be interpreted with caution. Extrapolation from model animals such as mice and ducks to other livestock species cannot be done directly, given the physiological differences, production cycles, and economic value between species. For this reason, the results of this study are more indicative and require validation through advanced research designed in the field or in semi-field conditions with real livestock species.

Furthermore, this study has several other important limitations that need to be observed. First, the economic loss estimates used are still based on secondary data from animal toxicology studies, which do not fully reflect the complexity of the farming system in the real world. Second, the economic model in this study has not thoroughly considered the variability of livestock product prices between regions. Although price ranges are obtained from national reference sources, local price fluctuations due to market demand, logistics distribution, and regional policies have not been analyzed in detail. Third, sensitivity analysis to economic parameters such as death thresholds, currency exchange rates, and inflation has not been conducted, which can affect the accuracy of loss estimates. Taking these limitations into account, we encourage the need for more comprehensive follow-up studies with a multidisciplinary approach, to strengthen the validity and generalization of the findings and make a real contribution to microplastic control policies in the livestock sector.

4 | Conclusion

This study aims to analyze the impact of microplastic exposure on economic losses in selected animals, namely laboratory white mice and duck embryos, based on secondary experimental data from various literature. The results showed that exposure to PET, PS, and PTFE microplastics can cause significant mortality rates, ranging from 20% to 80%, which are then converted into estimated economic losses per cycle and per year. The annual economic loss due to exposure to microplastics in duck embryos reached USD 6,859,091.14, while in rats it could reach USD 113,568. These findings suggest that microplastics are not only an ecological threat but can also cause significant financial losses to the livestock and research sectors.

This economic impact should be a major concern for policymakers, especially in drafting regulations related to the control of microplastics in animal feed and water. The government can set safety standards for microplastic content in livestock inputs, as well as encourage mitigation practices such as water filtration, feed raw material monitoring, and education for farmers. On the practical side, livestock actors are advised to start implementing preventive measures to protect animal productivity and prevent economic losses. This research can also be the basis for the formation of evidence-based policies to ensure the sustainability of the livestock sector in the face of plastic pollution.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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