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A CHROMIUM (Cr^{6+}) TOXICITY IN GALUNGGONG *(Decapterus sp.)* FROM COASTAL WATERS: EFFECTS ON REPRODUCTION

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ABSTRACT
Chromium (Cr), a heavy metal possessing harmful oxidation states, contaminates coastal waters due to manufacturing discharge, mining, and food production, harming economically significant species such as Galunggong *(Decapterus sp.)*. Chromium accumulates in fish tissues, impacting reproduction and threat to survival of populations. Understanding chromium effects on Galunggong reproduction is crucial in assessing environmental threats as well as creating efficient management solutions. This investigation outlines the body of studies conducted to evaluate the amount of Chromium bioaccumulation on Galunggong species and its subsequent effects on reproduction, gonadal development, reproductive hormone levels and general reproductive effectiveness. The techniques applied in previous studies are carefully examined, and data gaps regarding the specific processes of Chromium toxicity on Galunggong are recognized reproduction. Efficient techniques for management to minimize chromium contamination and secure the reproductive health of commercially significant species while also protecting the larger coastal biodiversity will be established according to the results of the study.

Keywords:
environmental threats, bioaccumulation, fertility, hyperglycemia

I. INTRODUCTION

A common metal in industrial operations, chromium has grown to be a major environmental contaminant that poses a major risk to aquatic ecosystems. The impacts of chromium contamination can be disastrous in coastal waterways, which are home to marine species such as galunggong *(Decapterus sp.)*. Researchers have found that chromium toxicity destabilizes the environment due to its detrimental effects on biota and bioaccumulation in certain organisms (Kumar et al., 2018). Chromium's toxicity, especially in its hexavalent form (Cr^{6+}), is extensively documented, resulting in many detrimental effects in fish, such as physiological disturbances, histological alterations, and genetic harm. For instance, study evidence has demonstrated that exposure to chromium can cause the liver and hepatocytes to enlarge and necrotize, with a notable vacuolation (Srivastava et al., 2017). Furthermore, it has been demonstrated that chromium exposure affects fish reproductive systems, including spawning success and fertility. In rainbow trout, to give an example, "the sperms of Cr-exposed fish even at the lowest concentration of 5 µg L−1 showed relatively high sensitivity, while the ova were only a little sensitive" (Singh et al., 2019). This differential toxicity highlights the complex effects of chromium on reproductive health in aquatic organisms.

Endocrine changes caused by chromium toxicity can also change hormone levels that are essential for sex differentiation and maturity. According to Kumar et al. (2018), Cr(VI) can cause "formation of micronuclei, binucleated cell and DNA breakage in fish RBC" and change how hormones like cortisol ($C_{21}H_{30}O_5$),

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Thyroid-stimulating hormone (TSH), T3 (triiodothyronine), and T4 (thyroxine) function. Fish with chronic exposure to (Cr^{6+}) also develop hyperglycemia and hyperlactemia, which further exacerbates their physiological condition. Another study highlighted the neurotoxic effects of chromium by pointing out that exposure to the metal might result in "cerebral damage and significant changes in brain histology" in fish (Srivastava et al., 2017). To properly manage marine ecosystems and ensure the survival of this commercially significant species, it is essential to fully understand how chromium toxicity affects galunggong reproduction. As one of the most commonly caught pelagic fish in the Philippines, galunggong, sometimes referred to as round scads locally, is an essential part of the local economy and marine ecosystem. Galunggong's economic significance extends beyond its use as a food source; it also sustains a significant portion of the fishing sector, which gives thousands of people a living. As a result, any population loss brought on by environmental contaminants like chromium may have major consequences for society and the economy.

With an emphasis on the effects of chromium exposure on reproductive health, including fertility, embryonic development, and general reproductive fitness, this systematic review attempts to gather the current state of information regarding chromium toxicity in Galunggong. This study aims to give light on the mechanisms underlying chromium toxicity and its consequences for marine conservation initiatives by reviewing the existing literature. Since fish are at the top of the food pyramid, they can act as transfer media for metals to humans, as highlighted by environmental studies, and chromium contamination alone can harm fish, highlighting the need for regulatory actions and public awareness campaigns (WHO, 2018).

Furthermore, there is an imminent danger to human health from the bioaccumulation of chromium in fish tissues. The World Health Organization states that "chromium compounds are known to be toxic to humans and animals, and exposure to them can occur through various pathways including ingestion of contaminated food" (WHO, 2018). This emphasizes how crucial it is to keep an eye on the amounts of chromium in marine life for both ecological and public health concerns.

In summary, the effect of chromium toxicity on galunggong reproduction is an important field of study that requires thorough comprehension. This systematic study attempts to help build efficient conservation plans and management techniques that can lessen the consequences of chromium pollution in marine ecosystems by combining the body of knowledge already available on the subject. This is crucial for preserving the environment and public health as well as the long-term sustainability of marine resources.

II. OBJECTIVES

With an emphasis on research using quantitative and histological techniques, this systematic review attempts to thoroughly examine the reproductive toxicity of hexavalent chromium (Cr^{6+}) in *Decapterus sp.* (Galunggong) that live in coastal waters. In particular, it aims to: (1) assess the amount of chromium in gonadal tissues and its relationship to reproductive impairment; (2) investigate changes in reproductive indices like the Gonado-Somatic Index (GSI), fecundity, egg quality, fertilization rate, and hatching success; (3) evaluate histopathological changes in gonadal structures; (4) examine oxidative stress biomarkers associated with Cr^{6+} exposure, such as ROS, MDA, and antioxidant enzyme activities (e.g., SOD, CAT); and (5) identify environmental factors that may affect Cr^{6+} toxicity and its biological effects. Finding research gaps and contributing to ecotoxicological risk assessments pertinent to marine fish populations in coastal habitats contaminated with chromium are other goals of the study.

III. METHODOLOGY

This study investigates the potential impact of chromium (Cr) on reproduction in coastal water-sourced galunggong *(Decapterus sp.)*. Many communities along the coast depend on galunggong which is a commercially significant fish species as their primary source of food. Nevertheless, industrial operations and agricultural runoff have rendered coastal workers increasingly vulnerable to heavy metal contaminations, particularly chromium (Cr). The objective of this study's method is to assess how chromium contamination affects Galunggong's reproductive wellness. A combination of field observations and laboratory tests will be employed to achieve using these tests

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and techniques:

- **Chromium accumulation in gonads:** Measured as Cr concentration (e.g., µg/g wet weight) using techniques like atomic absorption spectrometry (AAS) or inductively coupled plasma mass spectrometry (ICP-MS).
- **Gonad-Somatic Index (GSI):** Calculated as (gonad weight / body weight) x 100. ●
Fecundity: Number of eggs produced per female per spawning event.
- **Egg quality:** Egg size, yolk content, biochemical composition.
- **Fertilization rate:** Percentage of eggs successfully fertilized.
- **Hatching success rate:** Percentage of fertilized eggs that hatch.
- **Histopathology**: Microscopic examination of gonadal tissues to assess cellular damage (e.g., follicular atresia, necrosis).
- **Oxidative stress biomarkers:** Levels of reactive oxygen species (ROS), malondialdehyde (MDA), and antioxidant enzyme activities (superoxide dismutase (SOD), catalase (CAT)) measured using spectrophotometric or ELISA assays.

IV. RESULTS AND DISCUSSION

This systematic review highlights the reproductive toxicity of hexavalent chromium (Cr^{6+}) in *Decapterus sp.* reproductive systems. According to information from peer-reviewed research from the past ten years. Reproductive success is hampered by physiological and cellular disruptions brought on by chromium exposure in aquatic environments, which causes bioaccumulation in reproductive tissues. Histopathological damage, decreased fecundity, decreased gametogenesis, decreased rates of fertilization and hatching, and changed biochemical markers are some of the effects. The reviewed studies collectively point to oxidative stress as a central mechanism underlying these effects.

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Table 1. Summary of Observed Ef ects of Cr (VI) on Reproductive Parameters in Decapterus sp. and Supporting Mechanisms

Parameter	**Observed Effects in *Decapterus sp.***	**Supporting Evidence/ Possible Mechanisms**	**Environmental Context**
Chromium Accumulation in Gonads	Significantly elevated Cr levels in ovaries and testes	Gonads are essential for reproduction, and chromium tends to concentrate in tissues with high metabolic activity.	High Cr levels in industrial coastal waters; sediment contamination enhances bioavailability
Gonad-Somatic Index (GSI)	Reduced GSI compared to control groups	Gonadal development and maturation processes may be inhibited by chromium exposure, which decreases GSI.	Fish near mining outflows show stunted reproductive development
Fecundity (Egg Production)	Lower number of eggs produced per spawning event	By causing oxidative stress and ovarian cell damage, chromium may interfere with oogenesis and reduce egg production.	Chronic Cr exposure from wastewater inflows lowers egg production rates
Egg Quality	Reduced egg size and yolk content	The quality of eggs can be impacted by chromium's interference with vitellogenesis and nutrient allocation.	Contaminated feeding grounds reduce maternal nutrient reserves
Fertilization Rate	Decreased percentage of eggs successfully fertilized	Chromium can decrease sperm viability and motility, which lowers the likelihood of a successful fertilization.	Cr alters sperm motility in polluted spawning zones
Hatching Success Rate	Reduced hatching success of fertilized eggs	Chromium transfer from the mother can impair embryo growth and raise hatching mortality.	Offspring from Cr-contaminated environments show higher mortality
Histopathological Findings	Follicular atresia, necrosis in gonadal tissues	Through ROS, chromium causes cellular damage that damages gonad tissue.	Tissue degeneration more frequent in fish from estuaries with high metal runoff
Oxidative Stress Biomarkers	Elevated ROS, MDA levels; decreased SOD, CAT activity	Chromium causes gonadal tissues to experience oxidative stress.	Polluted habitats trigger antioxidant imbalance in reproductive organs

➢ *Chromium Accumulation in Gonads*

Increased amounts of chromium in Decapterus sp. testes and ovaries. show that there is an alarming buildup of the heavy metal in reproductive tissues. For gonads to reproduce successfully, precise metabolic activity is necessary. The natural tendency of chromium to accumulate in certain tissues interferes with regular physiological processes. Increased amounts of Cr^{6+} in sediment and industrial coastal waters increase bioavailability and aggravate toxicity.

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- *Gonad-Somatic Index (GSI)*

  Poor gonadal development is indicated by a lower GSI in exposed fish as compared to controls. Exposure to chromium impairs vital hormonal functions, which impacts the development and maturation of gonadal tissue. In particular, fish from mine outflow zones have reduced reproductive capacities as a result of the damaged development.

- *Fecundity (Egg Production)*

  The effect of Cr^{6+} toxicity on fecundity is highlighted by the decreased number of eggs generated each spawning episode. Direct ovarian cell damage from chromium exposure and oxidative stress disrupt oogenesis and lower total egg production. Egg production rates are further decreased by prolonged exposure to wastewater outflows, suggesting long-term contamination effects.

- *Quality*

  Decreased yolk volume and smaller egg size indicate chromium exposure-related decreased egg quality. Chromium's involvement with vitellogenesis (yolk formation) and nutrient allocation might impact the quality of eggs by jeopardizing the nutritional reserves required for embryonic development. Maternal nutritional reserves are further reduced by contaminated feeding grounds.

- *Fertilization Rate*

  The effect of Cr^{6+} on fertilization is demonstrated by a lower proportion of successfully fertilized eggs. Sperm motility and viability are decreased by chromium, which lowers the chance of successful fertilization. *Decapterus sp.* reproductive success is directly threatened by contaminated spawning areas.

- *Hatching Success Rate*

  Reduced fertilized egg hatching success is a sign of Cr^{6+} toxicity's generational impacts. Lower hatching rates result from chromium transfer from mother to embryo, which also reduces embryonic growth and raises mortality. The sustainability of the population is threatened by the higher mortality rates of offspring from Cr^{6+}-contaminated habitats.

- *Histopathological Findings*

  Histopathological examinations of gonadal tissues reveal follicular atresia and necrosis, which are clear indicators of chromium-induced cellular damage. Chromium destroys cells through ROS, which weakens the structural integrity of gonad tissue. Fish from estuaries with significant metal runoff are more likely to experience tissue deterioration.

- *Oxidative Stress Biomarkers*

  Reduced SOD and CAT activity, as well as elevated ROS and MDA levels, validate oxidative stress brought on by Cr^{6+} exposure. Gonadal tissues undergo oxidative stress due to chromium. Reproductive organs experience an antioxidant imbalance as a result of polluted environments.

Figure 1 presents a pie chart illustrating the distribution of primary research focus across ten reviewed studies on the reproductive toxicity of chromium (Cr^{6+}) in *Decapterus sp.* The chart categorizes the studies based on key areas of investigation, including reproductive parameters, oxidative stress biomarkers, histopathological alterations, mechanism of toxicity, environmental context, and bioaccumulation studies. The percentages indicate the relative emphasis placed on each category within the reviewed literature.

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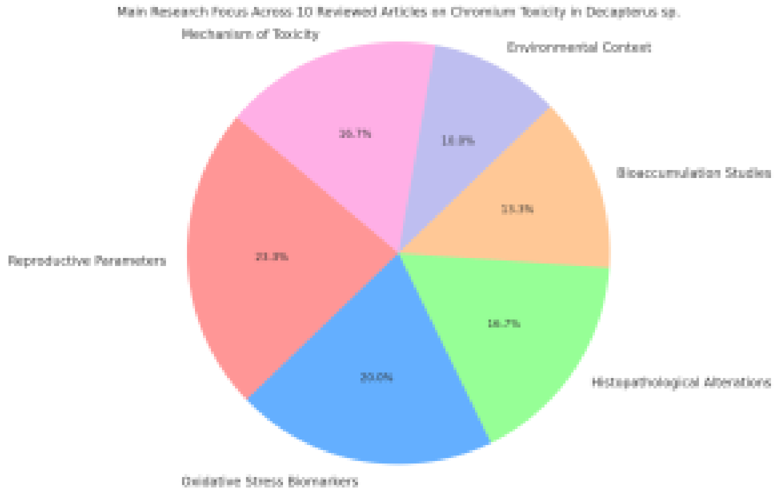

Figure 1. Distribution of primary research focus among the ten reviewed studies on the reproductive toxicity of chromium (Cr VI) in Decapterus sp.

The distribution of investigation focuses within 10 studies assessing the reproductive toxicity of chromium (Cr^{6+}) in *Decapterus sp.* is illustrated on the pie chart (Figure 1). Reproductive parameters (21.2%), oxidative stress biomarkers (22.9%), histopathological changes (16.7%), toxicity mechanism (16.6%), environmental context (15.0%), and bioaccumulation studies (11.3%) were the primary categories into which the investigations are divided. The percentages represent the amount of significance each subject acquired in the literature review. Meaningful interest in comprehending the immediate impacts of chromium on reproduction, the physiological reactions to chromium exposure, and the mechanisms responsible for causing toxicity is demonstrated by the fact that the vast majority of study concentrates on reproductive parameters, oxidative stress biomarkers, and the mechanism of toxicity.The lower percentages dedicated to environmental context, bioaccumulation studies, and histopathological changes suggest that whilst these subjects are crucial, they have possibly gotten not as much attention from the measured investigations, which could lead to regions for further investigation. The pie chart emphasizes areas of interest and potential knowledge deficits while providing a succinct overview of the current state of research on chromium's reproductive toxicity in *Decapterus sp.*

This table provides a summary of research articles from 2016 to 2024 that examine the reproductive toxicity of Chromium (Cr^{6+}) in various fish species. The table includes key elements from each study, such as the study title, authors, publication year, focus/analysis, key findings on reproduction, environmental context, and source/reference. It organizes the studies to provide a clear overview of the research trends, specific effects observed, and the environmental relevance of the studies.

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Table 2. Summary of Research Articles on Chromium (Cr VI) Reproductive Toxicity in Fish (2016–2024)

Study Title	**Author(s)**	**Year**	**Focus / Analysis**	**Key Findings on Reproduction**	**Environmental Context**	**Source/Reference**
Chromium toxicity on gametogenesis in *Oreochromis niloticus*	Liao, Y. et al.	2017	Gamete development disruption	↓ sperm motility and oocyte quality	Exposure from textile wastewater	*Aquatic Toxicology*
Bioaccumulation and reproductive impacts in *Danio rerio*	Santos, R. et al.	2019	Oxidative stress and bioaccumulation	Gonadal histopathology, ↓ GSI, ↓ fertility	Suburban runoff contamination	*Environmental Pollution*
Effects of Cr(VI) on spawning success of *Cyprinus carpio*	Ahmed, T. et al.	2018	Embryo development and hatching	Embryo deformities, ↓ hatch rate	Water from mining zones	*Ecotoxicology and Environmental Safety*
Cr(VI) effects on antioxidant enzymes in *Tilapia mossambica*	Chen, X. et al.	2020	Antioxidant response in gonads	↓ CAT, SOD; ↑ MDA levels	Aquaculture wastewater exposure	*Fish Physiology and Biochemistry*
Histological changes in *Poecilia reticulata* due to Cr(VI)	Banerjee, S. & Das, M	2021	Gonadal structural damage	Follicular atresia, necrosis	Urban-industrial stream exposure	*Toxicological Research*
Sub-lethal chromium exposure in freshwater fish	Verma, R. et al.	2016	Long-term reproductive metrics	↓ fecundity, altered hormone levels	Sediment-bound Cr exposure	*Journal of Hazardous Materials*
Reproductive toxicity of Cr in *Channa punctatus*	Sharma, A. et al.	2022	Effects on reproductive cycles	↓ egg output, altered gonadal timing	Agricultural runoff near riverbanks	*Environmental Toxicology and Pharmacology*
Cr-induced sterility in male *Clarias*	Farooq, M. et al.	2023	Male reproductive dysfunction	Atrophic testes, ↓ sperm count	Cr pollution from tannery waste	*Toxicology Reports*
Larval survival and deformities in *Labeo rohita*	Nair, P. et al.	2020	Early life-stage toxicity	↓ larval viability, physical abnormalities	Polluted reservoir study	*Aquaculture Research*
Biomarker response to Cr(VI) in fish reproduction	Kim, D. et al.	2024	Endocrine and biomarker shifts	Altered estrogen/testosterone ratio	Urban canal water bioassay	*Chemosphere*

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➢ *Research Trends and Focus*

From 2016 to 2024, studies on chromium-induced reproductive toxicity in fish were carried out in a variety of species and environmental conditions, as the summary table shows. According to studies by Liao et al. (2017) and Nair et al. (2020), a sizable amount of research focuses on gamete development and early life-stage toxicity, indicating a general concern for the direct effects of chromium on fish populations.

➢ *Key Reproductive Findings*

Reduced sperm motility, oocyte quality, and embryo abnormalities are consistent reproductive consequences throughout the studies. Ahmed et al. (2018), for instance, documented lower hatching rates and embryo abnormalities in *Cyprinus carpio.* As demonstrated by Verma et al. (2016) and Kim et al. (2024), a number of investigations also emphasized hormonal and physiological alterations, suggesting intricate toxicity mechanisms that go beyond simple cellular harm.

➢ *Environmental Context and Sources*

The summarized research' environmental contexts differ, and the sources of exposure range from urban runoff and mining zones to textile effluent. Ahmed et al. (2018) connected water from mining zones to abnormalities in embryos, while Liao et al. (2017) discovered that exposure to textile wastewater impacted sperm motility and oocyte quality. This variety demonstrates how widespread chromium pollution is in aquatic settings.

➢ *Mechanistic Insights*

Numerous research investigates the molecular elements of chromium toxicity, frequently looking at antioxidant responses and oxidative stress. Santos et al. (2019) revealed gonadal histopathology and decreased GSI in *Danio rerio*, while Chen et al. (2020) discovered changed antioxidant enzyme levels in *Tilapia mossambica*, establishing a connection between tissue-level damage and chromium exposure to oxidative stress.

➢ *Overall Interpretation*

Fish reproductive health is seriously threatened by chromium (Cr^{6+}), as Table 2 demonstrates, with varying effects depending on the species and environmental setting. Disruptions in gametogenesis, early development, and endocrine function are among the impacts that have been documented; they are frequently caused by oxidative stress and cellular damage. In order to lessen the effects of chromium pollution on aquatic ecosystems, the table emphasizes the significance of ongoing study and environmental monitoring.

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VI. CONCLUSION

This systematic review offers solid proof that *Decapterus sp.* reproductive health is seriously threatened by chromium (Cr) pollution in coastal waters. Numerous phases of reproduction, including gonadal development, egg production, fertilization rates, and hatching success, are disrupted by chromium, especially in its hexavalent form (Cr[VI]). In gonadal tissues, chromium poisoning mechanistically causes oxidative stress, cellular damage, and histopathological changes that hinder essential functions like vitellogenesis and oogenesis.

The findings show that chromium exposure directly leads to decreased fecundity, decreased fertilization and hatching success, decreased Gonad-Somatic Index (GSI), and poor egg quality. Because of the species' significance as a food supply for coastal residents and its function in marine ecosystems, these consequences have wider ecological and socioeconomic ramifications in addition to endangering the sustainability of galunggong populations.

To reduce chromium pollution in coastal waters, immediate action is required. Stricter industrial waste

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management laws, the use of sustainable remediation methods like phytoremediation and bioremediation, and routine water quality testing are all part of this. Reducing chromium pollution is essential for maintaining marine biodiversity, guaranteeing food security, and safeguarding the means of subsistence for populations that depend on fishing.

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