Creation of Defence Wall against Light Pollution for Saving the Invertebrate Ecosystem

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***Abstract*—Light pollution is affecting the nature's ecosystem in a very unfavourable way. This paper focuses on invertebrates and the main objective of this is to ensure their protection from the harmful effects of light pollution. Lights cause birds to become lost, which increases mortality, sea turtles' ability to navigate the ocean can be hampered by artificial light. Light pollution can affect food webs, lure invertebrates to artificial lights, disturb their circadian rhythms, and interfere with pollination, all of which can have detrimental consequences on ecosystems. More reviews on various studies that investigated the consequences of light pollution on a different invertebrate animals are provided here. This pollution harms invertebrate communities in various environments like streams, coral reefs. To prevent this and reduce the negative impact of light pollution on invertebrate biodiversity a number of strategies are being researched, including minimizing upward light transmission in parking lot and street lighting design, exterior lighting preservation, a reduction in high-intensity emissions, the use of motion sensors to turn off lights when not in use, and lowering or turning off the outside building and sign lighting if not needed.**

***Index Terms*—light pollution, invertebrates**

I. Introduction

A phenomenon brought on by human activity on a worldwide scale, light pollution, has a considerable negative impact on invertebrates as well as other creatures of the natural world. Most land and marine species lack spines, which play essential roles in maintaining the cycles and functions of biological systems. However, artificial light during the evening disturbs their usual patterns of behavior, leading to altered action plans, multiplication, development, living space organization, and correspondence. Numerous studies that have looked at how light pollution affects diverse groups of invertebrates have underlined the necessity for mitigation measures to protect the invertebrate ecosystem. For instance, it has been found that street lights draw more scavengers and predators, emphasizing the importance of considering location and time when putting mitigating techniques into place. Environmental light pollution (ELP) also changes coral physiology, dramatically lowers coral cover and diversity, and upsets the ecological harmony of the reef ecosystem. This emphasizes the requirement for mitigation strategies such the use of shielded lighting fixtures, a reduction in the quantity and duration of artificial light, and the promotion of light-free zones in sensitive areas. In order to protect the invertebrate ecosystem, this investigation aims to create a protective wall against light contamination. The impacts of light pollution on different invertebrate groups, such as mollusks, herbivores, marine organisms, and intertidal species, have been the subject of several research. The study also points up the need for mitigating strategies to decrease the effects of ELP on communities of stream and riparian invertebrate species as well as Talitrid amphipods [1]. In the end, the study examines methods for lessening light pollution's negative effects on invertebrate biodiversity. These encompass activities in policy and education, behavioral adjustments by individuals, and technical solutions.

II. Problem Detection

Invertebrates, as well as other ecosystems, are significantly impacted by light pollution, an anthropogenic phenomenon. Invertebrates' natural physiology and behaviors can be impacted by light pollution, which can have a detrimental effect on their ability to survive and reproduce. Finding the issue and comprehending how it affects invertebrates are therefore crucial. Behavioral observations are one technique for determining how light pollution affects invertebrates. To ascertain the effects of light pollution on invertebrates, researchers can observe how they behave under various lighting conditions. Researchers can determine how light pollution affects animals' natural behavior, for instance, by monitoring their activity patterns in locations with various light levels. Another method of determining the impact of artificial lighting on invertebrates is through physiological measurements. Researchers can check the levels of stress hormones in the animals to determine how light pollution affects their physiology. The physiological

impacts of light pollution on invertebrates can be better understood as a result. Another technique for examining how light pollution affects invertebrates is DNA analysis. Scientists have demonstrated how light pollution may impact genetic variety via DNA analysis. For instance, a study that examined the impacts of light pollution on moths and employed DNA analysis to demonstrate how genetic diversity may be influenced by light pollution was published in the journal Molecular Ecology [2]. Another technique for researching how light pollution affects invertebrates is the use of light traps. Invertebrates can be caught and seen using light traps in locations with varying levels of light pollution [3]. This can help identify areas that are particularly affected by light pollution and shed light on how various species respond to various types of light. Field studies are another method by which scientists look into the negative affects of light pollution on invertebrates. The effects of different lighting levels on invertebrates can be studied in experimental plots that researchers can set up. Light Pollution's effects on invertebrates and their ecosystems can be determined from this, which can yield useful information. Light pollution's effects on invertebrates can also be investigated in controlled laboratory studies. Invertebrates may be exposed to different lighting conditions while their responses, such as behavior, physiology, or gene expression, are monitored and recorded. The physiological and genetic effects of light pollution on invertebrates can be understood using this method, which can be very insightful. To sum up, it is critical to identify how light pollution affects invertebrates in order to safeguard these significant species and the ecosystems they rely on. For determining how light pollution affects invertebrates, it is useful to use behavioral observations, physiological measurements, DNA analysis, light traps, field experiments, and laboratory studies. Researchers and decision-makers can create effective strategies to lessen the harmful effects of light pollution and promote sustainability by better understanding how invertebrates are impacted by it.

III. Applied Method

Light pollution is a growing problem that affects not only people but also other animals like invertebrates in many parts of the world. They are particularly vulnerable to light pollution because many invertebrates have evolved to rely on natural light cues for vital life processes like reproduction and navigation. Light pollution can make these procedures more difficult, which will be bad for invertebrate populations. By using shields, hoods, and other types of lighting fixtures that direct light downward and reduce upward or outward light dispersion, invertebrates can be protected from the harmful effects of light pollution [4]. This is essential for outdoor lighting, like streetlights and parking lot lights, which significantly adds to light pollution. Invertebrates may be less negatively affected by light pollution if lights are used at lower intensities or for shorter periods of time. This can be achieved by using more energy-efficient lighting equipment, such as LED bulbs, or by turning off lights when not in use [5]. Invertebrates will be less affected by light pollution if red or amber lights are used instead of lights that are outside of that color spectrum. Invertebrates are less likely to be attracted to and sensitive to particular light colors, which explains this. Light pollution will be reduced overall and nighttime darkness will be maintained with the installation of motion sensors that only turn on lights when necessary. This is particularly useful for outdoor lighting in areas with little traffic or activity. Using a timer to turn lights off at specific times, such as after work hours, can help lessen the impact of light pollution on invertebrates. When nighttime illumination is an option, this is especially beneficial in commercial and industrial settings [6]. Promoting responsible outdoor lighting use and informing people about how light pollution harms invertebrates are two ways to reduce light pollution. This might entail working with local businesses and organizations to promote the adoption of best practices for outdoor lighting as well as educating the public about how light pollution affects animals.

IV. Research Obejective

The research mainly aims to find out a defensive method to mitigate the light pollution and save the ecological balance of the ecosystem. The existing defensive methods of light pollution are not quite active to solve the arising issue. So a unique protective system should be built up against the light pollution to save the lives of invertebrates. The objectives of research are as follows:

A. Analyzing the ways of occurrence of light pollution.

B. Finding out the specific types of light pollution affecting invertebrates.

C. To fix the issue of the defensive method against light pollution.

D. Finding out a uniques defensive system to save the ecosystem of invertebrates by minimizing light pollution.

V. Literature Review

Artificial light is the outcome of removing the whole darkness of the world.It has been studied by ecologists that the effects of natural light on living species regulate the biological interactions but it failed to investigate how the intensity of these light at high rate can bring a life threatening risk for invertebrate living organisms.In past few centuries the intensity of light increased in such way which badly harming the ecological balance of invertebrate wild.After a research process it had been mentioned that these artificial light causes light pollution.This light pollution is quite responsible for catastrophic consequences for both invertebrates in terrestrial and aquatic environment. Currently many researchers are working to defend the light pollution to save the ecosystem of the animal kingdom. Before defending, it is being studied about the bad effects of light intensity and how it changes the biological clock of the interactions of invertebrates by observing the different behavioral patterns of each living organism.

[9] says light pollution is caused by artificial light sources like street lights that disrupt natural cycles and interfere with

stargazing. It can affect the behavior and reproduction of various organisms, including snails and other mollusks. The increased use of night time artificial lighting is a danger to ecosystems as well as biodiversity. The perception of illumination is important for organisms to adapt to their environment, and artificial light can interfere with this. Gastropods are a diverse class of animals that are affected by light pollution. The study examines the quantification of two types of light pollution and how they affect gastropods [7]. Light pollution affects mollusks in various ways, including reproduction, growth, habitat orientation, and communication. Egg laying behavior, fecundity, hatchability, and survivability can all be impacted by changes in natural light patterns. Additionally, light plays a crucial role in synchronizing the nervous system to the external 24-hour day-night rhythm, and any alteration to this pattern can affect migration and daily rhythms in organisms. Biological rhythms vary among organisms and are influenced by various factors such as temperature, wind, and feeding.

According to [8] artificial lighting at night, such as street lights and industrial facilities, can disrupt the natural rhythms of both aquatic and terrestrial organisms. The effects of this light pollution are not yet fully understood, but it is clear that it can impact biological systems. One study found that a species of mollusk was particularly sensitive to different light conditions, affecting their reproduction, growth, and survival. To better understand these effects, researchers need to determine safe limits for nocturnal light exposure in terms of intensity, spectrum, and duration. Technological advancements may help mitigate the negative effects of light pollution. The study conducted a three-year experiment to investigate the effects of different types of street lighting on herbivores and plant cover in a grassland ecosystem. The researchers observed both direct effects on plant cover and indirect effects on herbivores through changes in predation rates. These findings suggest that artificial light can impact multiple levels in an ecosystem. In addition to analyzing experiments, the study also implemented methods for sampling vegetation and invertebrates. This included measuring plant cover and collecting leaf samples, as well as measuring the abundance of aphids and predators in the study area. The collected data was used to estimate the resources available to the aphids and to analyze the presence and absence of herbivores and predators in relation to light factors. The article discusses the ecological impacts of artificial light at night and proposes three principles of light design to mitigate these impacts, including avoiding illumination in natural and semi-natural ecosystems, limiting light intensity, and controlling emission spectra [8]. The authors emphasize the importance of considering both the environmental and physiological pathways through which artificial light impacts species and ecosystems.

[10] discusses the recent recognition of night time artificial light as an environmental concern and its impact on marine ecosystems. While research on the negative effects of artificial light on human health and land-based biological processes exists, there is little information on its effects on marine life. The article explores the sources of marine light pollution, its impact on depth-dependent biological processes, and defense mechanisms of marine life against predators. The article also discusses the need for research on the impacts of marine light pollution and suggests ecologically sound mitigation measures such as using narrow-band optical filters and LEDs to control the intensity and spectrum of artificial light.

[11] discusses the significance of extensive databases to comprehend how light pollution affects ecosystems and populations. It suggests concentrating on how light pollution indirectly affects related species and ecosystem health, and it suggests preservation efforts for naturally lit landscapes and marine dark sky parks. The article places a focus on the requirement for legal tools to lessen the ecological effects of marine illumination and a concerted research effort to create efficient preventative measures. The study mentioned in the article uses pitfall traps to detect the effects of light pollution on ground dwelling invertebrates and found that space and time play a significant role. It also found that cities with HPS street lights had more predators and scavengers near them.

According to [12] the effects of ecological light pollution (ELP) on coral reefs in the Gulf of Aqaba/Eilat. The study found that ELP significantly reduced coral cover and diversity, altered coral physiology, and disrupted the ecological balance of the reef community. ELP also increased the growth of algae, which can overgrow corals. The study suggests reducing the intensity and duration of artificial light sources and promoting light-free zones in sensitive areas to reduce the impact of ELP on coral reefs. The study highlights the need for further research to develop mitigation strategies and address multiple stressors that coral reefs face.

The article [13] discusses how France's intensive agriculture, impervious surfaces, and light pollution affect bat activity. The study used data from a national-scale monitoring program to examine the relative effect of these stressors on bat activity. The study found that light pollution had the strongest negative impact on bat activity, followed by impervious surfaces and intensive agriculture. The study suggests that reducing light pollution, especially in urban areas, could have a significant positive impact on bat populations. The study is important because bats play an important role in maintaining ecosystems and are important pollinators and insect control agents.

The article [14] investigates how during night the artificial light affects the seasonal and regular patterns of the nocturnal primate, Microcebus murinus. The study was conducted in the field, using light sensors and hormonal analyses. The results showed that higher levels of artificial light delayed the onset of estrus and reduced the breeding season. Additionally, light pollution disrupted the animals' daily activity patterns. The authors suggest that reducing light pollution is necessary to protect nocturnal primates and other wildlife. Overall, the study highlights the negative effects of light pollution on the reproductive success and survival of nocturnal primates, calling for further research and effective conservation strategies.

This study [15] investigated the effects of ecological light pollution (ELP) on invertebrate communities in streams and

riparian areas in Columbus, Ohio. The researchers measured ambient light levels and categorized ELP into three levels. They collected aquatic and riparian invertebrates and also added battery-operated LED lights to simulate extreme light levels found in highly developed urban areas. The study found that light levels had an impact on multiple invertebrate responses, particularly during the autumn, and that ELP significantly influenced measures of aquatic emergent insect during the October sampling period. The study suggests that artificial night lighting affects ecosystem function and has significant conservation implications as populations continue to urbanize. Further research exploring the effects of ELP in its many forms will be critical.

The study [16] looked at how ecological pollution of light affected the ecology and behavior of the Talitrid amphipod, Orchestoidea tuberculata, in sandy beach ecosystems. Field and laboratory experiments were conducted, and the results showed that exposure to light pollution significantly decreased amphipod activity and altered their circadian rhythm, with growth and consumption rates being lower under light pollution. The study highlights the emerging threat of light pollution on sandy beach organisms and the need for further research to understand its impact on different taxa and ecosystems. The study used statistical models for data analysis and the results were presented in tables. Overall, the study emphasizes the importance of considering this emerging threat in conservation efforts.

Human activities like pollution and destroying habitats have a harmful impact on wildlife populations and can even cause some species to become extinct. Loss of biodiversity can happen due to various factors like introducing new species, using too many resources, and environmental pollution, but habitat destruction is the biggest cause of extinction. Chemicals, minerals, oil spills, and acid rain can have disastrous effects on ecosystems that support wildlife. This paper explains how pollution from hydrocarbons, heavy metals, and tannery waste can damage phytoplankton, and how oil spills can have long-term effects on the immune systems and reproductive abilities of wildlife. Heavy metals can also negatively affect animal behavior, metabolism, and neurological processes. Acid rain, caused by burning coal and oil, harms forests by removing soil minerals and making it hard for fish and birds to reproduce, while also killing aquatic creatures. Light pollution can cause changes in behavior and physiology in wildlife, especially amphibians and salamanders [17].

The effect of light pollution on intertidal ecosystems is covered in this article. The effects of light pollution on intertidal species, which heavily rely on nighttime ecological strategies like feeding, reproduction, orientation, and predator avoidance, have received little attention despite being common in coastal areas. The study concentrated on the predatory mollusk dogwhelks' nocturnal foraging behavior because it affects the biodiversity of temperate rocky shores. The experiment looked at how dogwhelks' basal and foraging activity changed when exposed to nighttime lighting both with and without olfactory predator cues. The findings show that nighttime lighting had an impact on the intertidal fauna's behavior, which in turn affected the balance of interactions necessary for community structuring [18].

A study used statistical analysis in R 3.6.3 to investigate the effects of nighttime artificial lighting (ALAN) on nestling bird melatonin production, nitric oxide and haptoglobin levels, growth rate, and body mass after an immune challenge. As a result of exposure to ALAN, baseline levels of nitric oxide were found to be lower, but growth and body mass were unaffected. After the immune challenge, the nitric oxide levels in the birds from both night-raised and ALAN-exposed flocks were lower. Regardless of exposure to ALAN, body mass changes following the immune challenge differed among nestlings. There was no significant correlation between nitric oxide and haptoglobin levels before or after the immune challenge. The analysis included random effects and centered numerical covariates for easier understanding [19].

VI. Future Work

Research on the consequences of light pollution is necessary to comprehend how artificial light affects natural ecosystems. It is crucial to look into how light pollution affects an organism's ability to reproduce, grow, and survive in its natural environment. Such research is crucial for maximizing the effects of natural light on these processes and encouraging successful development. The physiological and ecological mechanisms by which various species are harmed by light pollution must be considered in order to achieve this. This requires looking into the consequences of light pollution in all of its forms, such as skyglow, glare, and light trespass, among others [20]. We can create effective conservation strategies to safeguard vulnerable species and their habitats by investigating these effects. For instance, reducing artificial light source duration and intensity can help to lessen coral reef effects from excessive light pollution. Such actions can help coral reefs, which are essential to the wellbeing of many marine ecosystems, grow and survive. Similar to how proper use of soil minerals can help shield the ecosystem from light pollution's harmful effects. In conclusion, it is essential to conduct research on the impacts of light pollution in order to comprehend how it affects natural ecosystems and create successful conservation plans. Developmental success can be achieved by enhancing the impact of natural light on reproductive, growth, and survival processes by examining the physiological and ecological pathways of light pollution.

VII. Conclusion

The effects of street lighting on ground-dwelling invertebrates, and they have revealed important ecological implications have been the subject of numerous studies. Due to these areas' proximity to the light source, predators and scavengers are drawn there, which is one of the major effects of the use of HPS street lights in urban areas. This may result in some species becoming more dominant while others become less so in communities of ground-dwelling invertebrates. By inhibiting the activity of the photoreceptors in the organisms

that inhabit an environment, the intensity of artificial light can also upset the ecological balance of that environment. Changes in the interactions and behavior of various species can have cascading effects throughout the food chain, contributing to further ecological imbalances. A concerted effort must made to understand the environmental and physiological mechanisms underlying the effects of artificial light on the environment as well as how various species react to them. Coral reefs and sandy beach ecosystems are just two examples of the many ecosystems that are at risk from ecological light pollution because there are currently no legal measures in place to help mitigate its effects. Numerous other factors, such as the careless use of synthetic chemicals, coming into contact with toxic minerals, oil spills, and acid rain catastrophes, already pose a threat to animal ecosystems. For instance, it has been demonstrated that nighttime lighting affects the intertidal fauna, which can have a significant impact on the interactional equilibrium necessary for community structuring. No matter how their physical development or body mass changed, birds exposed to artificial light at night were found to suffer negative effects, with a notable decline in initial nitric oxide levels being noticed. Overall, in order to duce its negative effects and safeguard the environment, it is crucial to understand how artificial night lighting has bad effects on ecosystem's functions and the preservation of biodiversity.

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