Light Pollution's Effect on the Visibility of the Orion Belt Throughout a Heavily Understudied Suburban Area

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Introduction

A topic of study for centuries, the night sky has not only fascinated scientists but also increased the understanding of the Earth; yet, as urbanization and industrialization grow, so does light pollution. To grow understanding of light pollution, the literature review will review six different studies on light pollution, its mitigation, and the methods used to conduct the study. To start, it will discuss the broad overall topic of light pollution in urban areas, then it will highlight the Bortle Scale and the specific study of light pollution. However, this focus on urban areas shows a clear gap in the research in suburban areas, which is where almost half of the American population resides. This gap is what leads to the research question discussed through this proposal, which is to study light pollution's effect on the visibility of the Orion Belt throughout a heavily understudied suburban area.

Literature Review

To start, it is important to define light pollution: “Light pollution is a form of environmental degradation in which excessive artificial outdoor lighting … affects the natural environment and the ecosystem” (Pun et al., 2014). Similar to the United States, cities such as Berlin in Germany face this: “The development of inexpensive light meters has led to measurement of the night sky luminance ...” (Kuechly et al., 2011). Multidisciplinary German scientists conducted a study correlating population density and light pollution, concluding and upwards trend of higher pollution, equally more light pollution (Kuechly et al., 2011). Similarly, other major cities like Hong Kong also collected data regarding the sources of light pollution in urban areas: “It is very common there to find poorly designed outdoor lighting that is not properly shielded. The majority of light is directed upwards towards the sky…” (Pun and So, 2011). This signifies a growing problem within urban cities due to poorly designed lighting. A study to understand this phenomenon was done by establishing monitoring stations in the urban and rural parts of Hong Kong. Three years later, these scientists broadened their study to 199 locations and 15 months of data collection, which represented 100 times more light pollution in urban than suburban areas (Pun et al., 2014). As all three sources discuss, artificial lighting not contained in buildings, such as the streetlights in the previous study, can lead to significant light pollution, especially in the highly populated urban areas.

To focus on this research project, it's important to define the Bortle Scale and its role in studying light pollution and night-sky visibility. The Bortle Scale measures the amount of artificial lighting in an area, which, according to Gronkowski and Wesolowski (2017), makes observing faint astronomical bodies difficult. Their study examined comet visibility using varying telescope strengths across different Bortle Scale classifications. Additionally, Balona and Dziembowski (1999) explored the visibility of pulsating stars based on high spherical harmonic degree models, finding that visibility depended heavily on observing techniques, particularly spectroscopy. This technique also correlated with Bortle Scale rankings. A recent study by Jägerbrand et al. (2021) analyzed how light pollution affects star visibility and ecosystems, revealing that turning off lights at certain times could enhance star visibility and benefit wildlife. While these studies primarily addressed urban areas, my research aims to fill the gap by investigating suburban locations. As stated above, it is increasingly significant to study suburban areas as the majority of the U.S. population lives there. As per a 2020 United States Department

of Justice synopsis, approximately 70% of the U.S. population lives in suburban areas, and with the lack of research regarding them, mitigation efforts can not be conducted.

Method

Astrophotography and a regression analysis are the best equipped elements of a method to research the topic discussed above. Northern Virginia is the chosen research location as it is a suburban area with a population of 2.5 million people (United States Department of Justice, 2020). For the astrophotography component, in total, a singular image will be composed for each of the 5 different areas, each in two-number increments on the Bortle Scale (e.g, 1-2 range or 4-5 range), with 5 total photos for the experiment. The actual process for collecting the pictures includes setting up a DSLR (Nikon 5100) and a tripod at each of the 5 locations on either a new moon or very low moon emitting period in the moon cycle. 300 pictures of my target will be taken (light frames), then 50 dark frames, 30 flat frames, and 50 bias frames. This diversity of frames is crucial for stacking the images to allow for limited noise during the regression analysis.

A regression analysis is chosen to see the effect of one independent variable, light pollution on different levels of the Bortle scale, on the dependent variable: the visibility of the Orion Belt. Two software programs will be employed to conduct this analysis (Roustaei, 2024). The first will have to be ImageJ/Fiji, which will allow the final images to be analyzed into numerical statistics ranging from 0-5, with the lower numbers representing better visibility of the orion belt (Fiji Downloads, n.d.). Next, the software R will actually conduct the regression analysis test by using lm() to earn a summary of results (Negoita, 2021). The summary function will reveal the statistical significance and relationship in data (Negoita, 2021). Analysis using credible software highlights how this method encompasses statistical analysis validity, and astrophotography presents for a long duration in the field, and unbiased data further showing validity

Conclusion

This study will provide the base of future research for the astronomy discipline, but the implications of the findings will apply to many demographics. To start, environmentalists can use the data that will be produced to understand how to start mitigation efforts. Additionally, local governments can further benefit the health of their cities and towns with a light pollution reduction initiative. Finally, those living in suburban areas can take this research as a call to action to mitigate light pollution throughout the U.S. before the problem is as full-scale as in urban locations. All in all, this study presents a plethora of future study ideas and sets the foundation to further close the gap in the lack of suburban light pollution research.

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