

The relationships between human visual range, $PM_{2.5}$ and meteorological factors in urban Taichung from 2013-2017

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Visibility has attracted significant attention in central and southern Taiwan, where the public perceive that the visibility has been declining over recent years. Human visual range (HVR) is determined by human eye observations and thus known to be more related to human's perception, unlike meteorological optical range (MOR) which is determined by optical-based instrument. Daily-average HVR, air pollutants and meteorological parameters in urban Taichung were acquired from the Taiwan Central Weather Bureau and Environmental Protection Administration, respectively, from 2013-2017. Descriptive statistics and regression analysis were carried out on the data to explore their relationships. The results show that both the HVR and $PM_{2.5}$ have been improving over the study period, from 10 km to 12 km and from $30.2 \mu\text{g m}^{-3}$ to $21.9 \mu\text{g m}^{-3}$, respectively. The relative humidity (RH) has increased from 70% to 75%, whereas the wind speed (WS) has maintained relatively stable at an average of 1.4 m s^{-1} . Using 10 km and $35 \mu\text{g m}^{-3}$ as cutoffs for high/low visibility (HV/LV) and high/low PM (HPM/LPM), the percentages of LV days have decreased substantially from 36% to 14%, and that they are more prominent during spring and winter. It is noteworthy that LV days are near-equally associated with LPM and HPM. Given that there is a moderate negative relationship between HVR and $PM_{2.5}$, this highlights that LV does not necessarily indicate high $PM_{2.5}$ pollution, and other factors come into play as well. In particular, RH is a strong modifier of the HVR and $PM_{2.5}$ relationship; poor visibility could occur under LPM but high RH, whereas good visibility could occur under HPM but low RH. The roles of WS and wind direction are less obvious, though stagnant condition ($< 1 \text{ m s}^{-1}$) and northwesterly winds are conducive to poor visibility in urban Taichung. In conclusion, we find that HVR and $PM_{2.5}$ have concurrently improved over recent years, contrary to public perception. In addition, there is a negative correlation between HVR and $PM_{2.5}$; however, $PM_{2.5}$ alone cannot explain the variability of HVR and, in particular, the RH is an important modifying factor.