Barriers as a Form of Air Pollution Concentration Reduction in Neighborhoods Near Roadways

A perpendicular wind pushing vehicle emissions toward a solid barrier will physically redirect the roadway emissions up and over a barrier. The lofting of the air mass over the barrier induces mixing, which will allow the emissions to be diluted with presumably less-polluted air, which effectively improves the air quality and reduces air pollution exposure in downwind communities[1,2]. Solid barriers such as sound walls have been the primary study target due to the uniform nature of the installation from location to location, unlike barriers made with vegetation due to the variation in vegetation[1,2].

The measurement studies and resulting modeling show that the effectiveness of barriers will depend on the porosity of the barrier and the width of the barrier[1,2]. Studies have shown that a solid, non-porous sound wall is very effective, while a wall of vegetation only can be less effective depending on the density of the barrier and the width of the barrier.[1,2] A combination of solid wall and vegetation may be slightly more effective due to the overall width of the barrier creating both more distance from the source.[1,2] Leaf deposition of air pollution is less effective than the mixing caused by the lofting of the source pollution of a barrier [1,2]. Vegetative barriers, solid barriers, and vegetation added to existing solid barriers have seen similar results in the dilution from mixing, with both the porosity and the width of the barrier being essential to the mixing effect [2]. The more porous barriers, such as vegetation only, will gain some of the lofting dispersion yet allow some undiluted air pollution to pass through.[1,2]

The barrier's geometry will vary the effectiveness of the mixing effect. A barrier installed perpendicular to the primary wind direction will have the most significant mixing effect from the pollution sources in front of the barrier[2]. This mixing effect is reduced as the wind speed is reduced, and the mixing will be reduced as the wind direction is more parallel to the barrier[2]. Mixing from a barrier can be effective, but it should be noted that the air pollution from the sources themselves is never reduced. A barrier can reduce mixing on the source or vehicle side of the barrier, and models show an increase in concentration before the air mass is pushed over the barrier during purely perpendicular wind conditions[2]. The timing of meteorology and the emissions also affect the effectiveness of the barrier. If the wind is not blowing during the rush hour, for example, then the air quality benefits and the exposure reduction are not fully realized in downwind communities.

Barriers do not reduce the emissions from the sources, but help reduce the exposure downwind of the sources by inducing or enhancing mixing, presumably with less polluted air, which reduces the pollution concentration downwind. Factors including prevailing wind direction, geography, the width of the barrier, the type of barrier or vegetation, and the cost of care and maintenance should be considered when contemplating installations.

References

1. Barwise, Y., Kumar, P. Designing vegetation barriers for urban air pollution abatement: a practical review for appropriate plant species selection. *npj Clim Atmos Sci* **3,** 12 (2020). https://doi.org/10.1038/s41612-020-0115-3 https://www.nature.com/articles/s41612-020-0115-3#:~:text=Indeed%2C%20numerous%20studies%20have%20found,offs%20in%20plant%20selection')
2. Zheming Tong, Richard W. Baldauf, Vlad Isakov, Parikshit Deshmukh, K. Max Zhang,Roadside vegetation barrier designs to mitigate near-road air pollution impacts,Science of The Total Environment,Volume 541,2016,Pages 920-927,ISSN 0048-9697,https://doi.org/10.1016/j.scitotenv.2015.09.067. (https://www.sciencedirect.com/science/article/pii/S0048969715307270) https://scholar.harvard.edu/files/ztong/files/online.pdf

Other Information & Links

Recommendations for vegetation:
https://www.nature.com/articles/s41612-020-0115-3#:~:text=Indeed%2C%20numerous%20studies%20have%20found,offs%20in%20plant%20selection')

Modeling study with technical details:
https://scholar.harvard.edu/files/ztong/files/online.pdf

EPA synopsis referencing the Hyphae vegetative barrier demonstration project
https://www.epa.gov/sites/default/files/2016-08/documents/recommendations_for_constructing_roadside_vegetation_barriers_to_improve_near-road_air_quality.pdf

Example of an installed vegetative barrier installed by Hyphae and referenced by the EPA:
https://medium.com/hyphae-design-laboratory/cleaning-the-air-through-ecosystem-interventions-e1da5eaf85f7

CARB sound wall study:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7092696/
https://www.arb.ca.gov/research/single-project.php?row_id=65195