Impact of cement factory emission on air quality and human health around Mugher and the surrounding villages, Central Ethiopia

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Abstract

PM2.5 and PM10 and CO_2, NO_2, and SO_2 emissions measured in different units of Mugher cement factory and nearby residential areas. The prevalence of respiratory system diseases of the community proximate and distant from the factory was also analyzed using clinical records. The emission dispersion pathways were also investigated using READY HYSPLIT Dispersion Model and wind rose diagram. Results show the mean ambient air quality PM2.5 (120–973 µg/m3) and PM10 (140–998 µg/m3) at the Mugher cement plant and $PM_{2.5}$ (106–198 µg/m3) and PM_{10} (101–303 µg/m3) at a nearby village. Emissions were above 150 µg/m3 prescribed by Ethiopian ambient air quality guidelines. Acute bronchitis (37.4%), chronic bronchitis (20%), and skin infection (15%). Based on age, 0 to 14 (50.8%)15 to 60 (47%).

Introduction

There has been no detailed study on the health status of the communities residing near cement factories in relation to cement emission. An integrated approach of identifying cement factory emission levels in and outside the factories and their impact on human health, which is lacking in most research undertakings, is required for possible mitigation actions. Therefore, the aim of this study is to assess the air quality in and outside the Mugher Cement Factory and its impact on the residents of the surrounding villages. This is to identify areas most affected by dry deposition during emission transport. The retrospective clinical records of respiratory and cardiovascular cases from the nearby health center were also investigated to see the possible relationship with the cement emission.

Methodology

Measurements were done from May 10 to 14, 2019, in the morning from 9 to 11 a.m. and in the afternoon from 2 to 5 p.m., for five consecutive days at all sites. ($PM2._5$, PM10), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon dioxide (CO_2). Aeroqual PM2.5 and PM10 sensor head; the NO_2, SO_2, CO_2 measured using gas sensors Aeroqual series 500 monitor (S-500) with a head sensor .

Clinical data were collected from the Mugher health center from January 1, 2010, to December 30, 2018, and the Inchini health centers from January 1, 2015, to December 30, 2018. Patients were categorized under case and control groups.

Analysis

Emission trajectory, dispersion, and deposition using web-based online READY HYSPLIT Dispersion Model

Wind speed at 10 m:READY (Real-Time Environmental Applications and Display System)

$$AQI_{pollutant} = \frac{Pollutant\ data\ reading}{Standard} \times 100$$

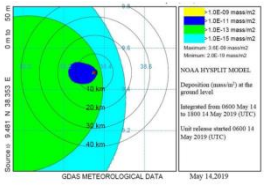
Relationship between exposure to emission and health outcome

$$Relative\ risk = \frac{\frac{Numbers\ of\ exposed\ cases}{Numbers\ of\ Unexposed\ cases}}{\frac{Numbers\ of\ exposed\ controls}{Numbers\ of\ Unexposed\ controls}}$$

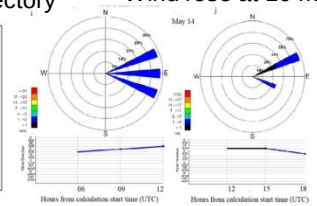
Results

- (PM2.5) in the Mugher cement plant was 120–973 µg/m3 , near by villages 106–198 µg/ m3 ; distant areas , 56–111 µg/m3 ; and Rejii, 46–91 µg/m3 . The PM_{10} in the Mugher cement plant was 140–998 µg/m3 ; nearby, 101–303 µg/m3 , distant area, 11–128 µg/m3 ; and Rejii, 82–193 µg/m3 .
- Gaseous pollutants with in the permissible limits.

Emission dispersion trajectory



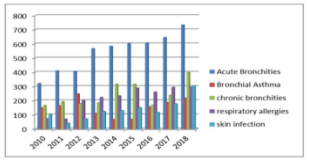
Wind rose at 10 m



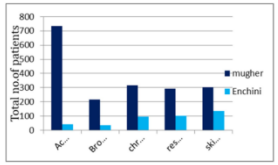
Disease Prevalence among different age groups

Age	Type of diseases					Total	Percent
	Acute bronchitis	Bronchial asthma	Chronic bronchitis	Respiratory allergies	Skin infection		
0–14	520	40	173	109	154	996	50.9
15–60	199	176	222	185	149	931	47.6
≥61	14	8	4	2	1	29	1.5
Total	733	224	399	296	304	1956	100

Prevalence of disease



Case vs. control



Conclusions and Recommendations

- Particulate matter emissions were above WHO ambient air quality standard. The factory and nearby villages show the highest particulate matter emissions
- Clinical records of the residents living in the vicinity of the cement factory, children and adults were highly affected by respiratory and infectious diseases
- Implementing a clean production system would reduce particulate matter emission
- Distancing the residential areas from factory production lines, applying regular monitoring, raising the awareness of the communities and workers, wearing protective cover by the workers, and regulatory enforcements could ease the impact of particulate matter emission on respiratory and infectious diseases