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A COMPREHENSIVE SURVEY OF WET SCAVENGING MECHANISMS FOR PARTICULATE MATTER

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Abstract : In this study, numerous approaches used in research from 2009 to 2023 are discovered by studying several research papers. A lot of studies have concentrated on characterizing particulate matter chemically and by measurement. The bulk of studies, however have indicated that $PM_{2.5}$ particles are significantly more significant because they are the root of global climate changes, health issues and visibility impairment. Recent research confirms that the duration and intensity of rain, particularly in the below-cloud scavenging process have an impact on scavenging of particle aerosols and can change the air quality index. According to some researchers, wet scavenging has been a popular method for eliminating particulate matter on a worldwide scale recently and precipitation can reduce particulate matter concentration.

IndexTerms - particulate matter, Rainfall, meteorological condition and scavenging process

I. INTRODUCTION

We are observing that atmospheric particulate matter has caused a major decline in air quality, which will continue to raise the global pollution level. Many types of research have been doing on the characterization of particulate matter. But in the past two decades, many types of research were focused on the measurement and chemical characterization of particulate matter [1-5]. The wet scavenging of particulate matter in monsoon is higher than in non-[monsoon season [6-7, 1].

The health of humans is harmed by particulate matter (PM) with an aero-diameter of less than 10µm, which can lead to number of respiratory and cardiovascular conditions as well as early death worldwide [8]. A significant issue with the air quality in many Indian cities is the excessive concentration of particulate matter [9]. When particles contact and combine with raindrops, scavenging of atmospheric aerosol particles occurs in both cloud and below-cloud scavenging. Typically, the wet scavenging of aerosol particles in below-cloud scavenging is characterized on the idea of a collision between rain droplets and particulate matter, including the effects of inertia, Brownian diffusion, thermophoresis, diffusionphoresis and electro-scavenging [10]. Scavenging is a method that removes pollutants from the air and is crucial in the transfer of pollutants from the air to the ground [11]. Therefore, the most crucial processes are those that make sure that the origins and outflow of aerosol particles are kept in balance [12]. Rain, snow, fog and ice are just a few of the several types of precipitation that can remove particles from the air. This phenomenon is known as wet below-cloud scavenging. One of the significant precipitation mechanisms, rainfall is crucial in removing air contaminants from the atmosphere [1]. In comparison to non-monsoon seasons, the wet removal process is more successful during the monsoon season. The impact of meteorological factors such as wind speed, wind direction, temperature and relative humidity. On particle change, transport and deposition on the other hand, is significant. Analysis of the washout effect's relative impact on the major air pollutants and a determination of the relationship between those major air pollutants are the study's goal.

II. LITERATURE REVIEW

U.C kulshrestha et al (2009)[1]- Real-time simultaneous studies on chemical characteristic of rainwater and PM_{10} aerosols were carried Indian region. The maximum scavenging ratio (SR) was observed for Ca^{2+} (74%) during rain, indicating that below-cloud scavenging is an efficient removal method for Ca^{2+} in the Indian region. Since calcium carbonate is abundant in soil dust and has been linked to crustal effect, Hyderabad's Ca^{2+} component had the greatest SR among non-sea salt components. However, throughout time, the concentration of these important chemical components gradually increased.

B.vijay Bhaskar,**Vikram** (2010)[13]- In this study data on airborne particle pollution were gathered in Ahmedabad over the course of four years, particulate pollution concentration in Ahmedabad decreased steadily during the course of this study period. These particulate pollution levels were compared to weather factors as temperature, humidity, rainfall and wind speed. Significantly unfavourable relationships with rainfall were seen for both SPM and PM10. Based on the AQI scale, it is determined that Ahmedabad's air quality is in the moderately unhealthy level.

Owoade et al. (2012)[14]- Seasonal fluctuation was noted in this study, with high concentrations in the dry season and low concentrations in the wet season. The investigation came to the conclusion that daily changes in the mass concentration of $PM_{2.5}$ and $PM_{2.5.10}$ are significantly influenced by meteorological factors. March (during the dry season) saw the highest mass concentration of particulate matter due to air haze, while July (during the wet season) saw the lowest mass concentration were found between the mass concentration of $PM_{2.5}$ and $PM_{2.5.10}$ and meteorological variables such wind speed, air temperature, relative humidity, and solar radiation.

Suhyang kim et al. (2014)[15]- The inter-events time criterion of 6 hours was used in this study to categorize precipitation data for 10 years in Seoul as independent rainfall events. When it rained, PM_{10} and NO_2 concentrations in the atmosphere were lower than when it didn't and an obvious change in average PM_{10} concentrations was seen. Due to the mobile emission effect, there was also a somewhat weaker link between precipitation and a drop in NO_2 levels in metropolitan areas.

Tomasz Olszowski et al. (2015)[16]- Using a reference approach, the measurements of the PM_{10} concentration were carried out during concurrent recording of the fundamental meteorology data. It was discovered that the kind of precipitation and rainfall intensity R have a significant impact on the scavenging effectiveness for PM_{10}. Data on A are only tangentially related to the "classical approach" of rain scavenging in the case of convective precipitation. The type of wet deposition (aside from storms), within the range of comparable values of rainfall intensity, has little effect on how well PM_{10} is removed from the ground-level zone.

Tomasz Olszowski (2016)[4]- the assessment of the removal of PM_{10} by widespread precipitation under no-wind conditions in background (rural) and areas is the focus of this article. From 2007 to 2013, the variations in PM_{10} concentration before, during and after rainfall were examined. The gravimetric reference method was used to determine the PM_{10} concentration. The removal coefficient © value and rainfall intensity and duration were shown to be linearly related. It was discovered that in places with poor air quality, the effect of the purification by wet deposition temporarily interacted less.

Hamed Biglari et al. (2017)[17] The study looked at the amount of particles in the air over the Iranian city of Qom. The results showed that the highest mean PM levels were recorded in September through October, followed by $PM_{2..5}$ in March through April and PM_{10} in May through June. The results revealed a positive association between PM_{10} and temperature (P=0.04 & r=0.35), a negative correlation with humidity (9value=0.001 & r=0.57), and a positive correlation with rainfall (P=0.04 & r=0.35). The findings also showed that there is evidence for a direct correlation between dust fall and temperature (9value=0.014 & r=0.85) and a reverse correlation between dust fall and humidity (Pvalue=0.03 & r=0.79).

Tomasz Olszowski (2017)[18] The study compared the effectiveness of liquid precipitation at scavenging PM_{10} in the warm and cold seasons of the year. The results are presented in paper. It was said that for all types of precipitation with a mean intensity of R>0.5 mm h1, the value of the removal coefficient assumes identical values in both the cold and warm seasons. It was said that the values of the mass concentration of particulate matter in the ground-level zone could alter the value of the removal coefficient for precipitation with low intensity.

Katalin Bodor et al. (2019)[19] From 2008 to 2019, the PM_{10} concentration variation before, during, and after the rainfall was monitored. The PM_{10} concentrations were lower in the cold and warm phases following the rainfall occurrence, at 2.8 ug/m^3 and 2g/m^3, respectively. The average reduction in PM_{10} concentration throughout the cold and warm seasons was 22.3% and 16.1%, respectively. The maximum PM_{10} concentration reduction was observed in cold season by the moderate and light rain intensity, following 6 hours of continuous rain (35.61%-32.46%).

Saurabh Sonwani et al. (2019)[2] Before rain (BR), during rain (DR), and after rain (AR) events were used to obtain PM_{10} samples. While the SR of EC displayed a modest link with rain intensity, the SR of OC revealed a strong positive correlation with rain intensity, the SR of OC revealed a strong positive correlation with rain intensity. When compared to monsoon season, the SR of EC was substantially greater during non-monsoon. Based on the particle size, source, and hygroscopicity of both types of carbonaceous aerosol, these features can be described.

Yiming Wang, Li He (2020)[20] In this study, it is shown that nighttime precipitation has clear seasonal characteristics, differs from daytime climate boundary conditions, and significantly affects the movement and modification of atmospheric pollutants. The result demonstrate that wet deposition may effectively eliminate air particle contaminants, and that nocturnal precipitation is more successful than daytime precipitation at doing so. It is discovered through categorization debate that the more intense the downpour, the longer it lasts, the larger the particles size, and the more visible the benefit of night rain.

Bin Zhou et al. (2021)[21] To determine how precipitation affects the removal of aerosol particles from the atmosphere, a "rain-only" method is not only original and distinctive, but it is also very easy to use and can be readily modified to forecast aerosol particle scavenging over any location on the planet. The results demonstrate that higher concentrations, more intense rain, and larger particle sizes result in higher scavenging rates and efficiencies.

Wing Sze Chow et al. (2022)[22] A 10-year dataset of $PM_{2.5}$ major components and source-specific tracers was examined in this work. The seasonal and trend decomposition of the pollution time series was performed using the locally estimated scatter plot smoothing (LOESS) and general least squares with autoregressive moving average methods. All of the key components of bulk $PM_{2.5}$ showed a considerable drop throughout the ten-year period to varied degrees. The long time series analysis linked the anomaly to very low rainfall associated with serve La Nina occurrences. The year 2011 was an outlier in the overall trend, having greater concentrations of $PM_{2.5}$ and its components than its surrounding years.

Jianyun Lu et al, (2023)[23] In this study a growing amount of research has connected particulate matter to respiratory illnesses. There are, however, few investigations on the connection between ILI (influenza-like disease) and PM_1 (particulate matter with aerodynamic diameter 1μm). This study's goal was to look into how PM affected ILI in Guangzhou, china.

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III. RESULTS OF THE SELECTED STUDIES

Year	Authors	Title	Research findings	References
2009	U.C Kulshrestha	Real-time wet scavenging of major chemical constituents of aerosols and role of rain intensity in Indian region	Continuous rain episodes of low intensity that prevented the accumulation of aerosol concentrations resulted in the greatest drop in aerosol levels (BR minus AR).	[1]
2010	B.Vijay Bhaskar	Atmospheric Particulate Pollutants and their Relationship with Meteorology in Ahmedabad	The result show that Ahmedabad's air quality is in the moderately unhealthy level.	[13]
2012	Owoade	Correlation between particulate matter concentrations and meteorological parameters at a site in ileife, Nigeria.	In this study weak linear correlations were found between the mass concentration of $PM_{2.5}$ and $PM_{2.5.10}$ and meteorological variables such wind speed, air temperature, relative humidity and solar radiation.	[14]
2014	Suhyang Kim	Effect of precipitation on Air Pollutant concentration in Seoul Korea.	The result shows that in urban areas, a relatively lower correlation between precipitation and reduction of NO_2 concentration was also observed, most likely due to the mobile emission effect.	[15]
2015	Tomasz Olszowski	Concentration changes of PM_{10} under liquid precipitation conditions	The results of experimental observations, which can be more useful in describing the variability of particulate matter pollution in the atmosphere than laboratory measurements, can be applied in models of dispersion and deposition of pollutants.	[16]
2016	Tomasz Olszowski	Changes in PM_{10} concentration due to large-scale rainfall	In places with poor air quality, the immediate purification effect brought on by the occurrence of moist deposition is reduced to a minimum.	[4]

2017	Hamed Biglari	Relationship between air particulate matter and meteorological parameters	Particulate matter concentration is influenced by a number of meteorological factors, including temperature, relative humidity, wind speed and wind direction. The concentration of air suspended particulate matter is increased by all of these factors.	[17]
2017	Tomasz Olszowski	The removal efficiency of dust during short-term rains-verification of additional factors	The result show that the values of the mass concentration of particulate matter in the ground-level zone could alter the value of the removal coefficient for precipitation with low intensity.	[18]
2019	Katalin Bodor	PM_{10} concentration reduction due to the wet scavenging in the Ciuc Basin, Romania.	The statistical data-based pearson correlation demonstrates the strong link between the length of rainfall and the reduction in PM_{10} concentration.	[19]
2019	Saurabh Sonwani	PM_{10} carbonaceous aerosols and their real-time wet scavenging during monsoon and non-monsoon seasons at Delhi, India	The present study found that for OC and EC, non-monsoon values were greater than monsoon values.	[2]
2020	Yiming Wang	Effect of rainfall intensity on PM_{10} and $PM_{2.5}$ scavenging in Guangzhou at night	It is found that rainfall can effectively remove atmospheric particulate pollutants, and the removal rate of PM_{10} is greater than the removal rate of $PM_{2.5}$	[20]
2021	Bin Zhou	A simple new method for calculating precipitation scavenging effect on particulate matter: based on five-year data in eastern china.	The wind diffusion effect and the precipitation scavenging effect both had an impact on particle air pollution scavenging. The most crucial element in maintaining ecosystems equilibrium with regard to air pollution is precipitation.	[21]
2022	Wing Sze chow	Measurement report: The 10-year trend of $PM_{2.5}$ major components and sources tracers from 2008 to 2017 in an urban site of hong kong, china.	The usefulness of chemical composition data in support of an evidence-based strategy for control policy formulation is demonstrated by this 10-year trend analysis based on measurements.	[22]
2023	Jianyun Lu	Short-term effect of ambient particulate matter (PM_1, $PM_{2.5}$ and PM_{10}) on influenza-like illness in Guangzhou, China.	The result show that PM_1, $PM_{2.5}$ and PM_{10} risk factors for illness, the health impacts of PM pollutants vary by particle size.	[23]

IV. CONCLUSION

In this paper, wet scavenging's effectiveness at removing PM_{10} concentration is discussed, along with the numerous approaches that have been employed in practice. After conducting a thorough examination of the literature, the authors used inclusion and exclusivity criteria to weed out 14 studies that were pertinent. The majority of the chosen research claimed to have achieved their desired accuracy. Based on this analysis, the scientists concluded that persistent rain events of low intensity precluded the accumulation of aerosol concentration.

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