

PARTICULATE MATTER EMISSION SOURCES AND THEIR CONTROL TECHNOLOGIES

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(Received 9 September, 2021; Accepted 25 January, 2022)

ABSTRACT

Particulate matter (PM) is a complex form of air pollution that includes all types of solid and liquid droplets present in the atmosphere. Primary PM Emission rates, sizes, and composition are difficult to predict since they rely not only on the industry, but also on the fuel properties, infrastructure, and other aspects of the emission process. Normal (volcanic eruptions, forest fires, and weathering of parent material and sea salt) and anthropogenic (power plants, internal combustion engines, and the thermo-degradation process) sources of airborne particulate matter exist. In order to uphold human health conditions and a clean climate; it has become important to reduce PM concentrations. Given the negative effects of particulates, their regulation is becoming increasingly necessary. In this article, we look at all of the origins of particulate matter, their negative consequences, and the monitoring systems that are used to minimize PM emissions. However, manufacturing and plant operations will get the most attention because they are the backbone of a country's economy as well as one of the largest causes of PM pollution and traffic regulation.

KEY WORDS : Particulate Matter, Organic Carbon, NEQS, Aerosols, WHO, Vehicular Exhaust

INTRODUCTION

Particulate matter (PM) contamination has been evolved all over the world, with the majority of the cases occurring in developed countries. According to the World Health Organisation, high particulate matter exposure will shorten life expectancies by up to 5.5 years (Colbeck, *et al.*, 2009). Controlling air pollution in Pakistan has not yet become a critical

problem due to a lack of appropriate knowledge for management and policy making, despite the presence of several rare studies identifying airborne particulate matter as a major health and environmental threat in Pakistan's major cities (Colbeck, *et al.*, 2009). Many international agencies and governmental organizations have found that air pollution poses a significant threat on citizens' health, the climate, and their quality of life (Wippich,

et al., 2020). Particulate matter is a diverse category of air pollutants with distinct features and effects depending on their nature and extent. It is difficult to estimate the sizes, emission rates and composition of PM due to its reliance on industries as well as other aspects of emission process such as fuel properties and infrastructure. PM are also considered as atmospheric aerosols that are referred to tiny particles consisting of liquid or solid droplets suspended in the air ranging from $PM_{2.5}$ to PM_{10} to Total Suspended Particles (TSP), while PM_4 was also identified as the respirable size fraction (Wippich, *et al.*, 2020). PM_{10} (coarse particle) are of size less than 10µm in diameter, while $PM_{2.5}$ (fine particles) are particles with size less than 2.5 µm in diameter and ultrafine particles less than 0.1 µm in diameter present in ambient air and may particularly toxic (Munir and Mayfield, 2021). Particulate Matter (PM) is divided into four main categories according to type and sizes as shown in Table 1 (Chen *et al.*, 2017). The features of PM mainly depend upon the origin, source and weather condition of the particular geographical area (Memhood *et al.*, 2018; Grahame, *et al.*, 2014).

Globally, major sources of $PM_{2.5}$ which are shown in Fig. 1 are primary environmental pollutants causing air pollution, water pollution, solid waste

pollution, and pollution from the growing number of vehicles on the roads, smoke from bricks kiln, power plants and steel mills, large-scale losses of trees, burning of garbage, coal and other biomass, such as crop residue, wood etc. in stoves, dust storms and forest fires (Munir and Mayfield, 2021).

Organic carbon (OC) as well as black carbon (BC) consists of 50%-70% of aggregate particulate matter emission. Based on the types of burning stage, the portion of BC and OC in biomass ranged from 1:8 to 1:12 (Chen, *et al.*, 2017). An inorganic element such as chlorine, potassium and calcium represents 10% of aggregate PM emission roughly (Memhood, *et al.*, 2018).

Sources and Effects

Poor air quality is one of the most pressing environmental issues of the twenty-first century, and its consequences are becoming more visible. It has had a significant impact on standard of life and human health in recent decades, and now it is considered as one of the biggest environmental threats to the human being for surviving quality life (UNECE, 2020) and the hazardous source of pollution. Last year, mortality was about 6.5 million people worldwide (WHO, 2016). Per annum, premature mortality rate is 5.5 million as a result of

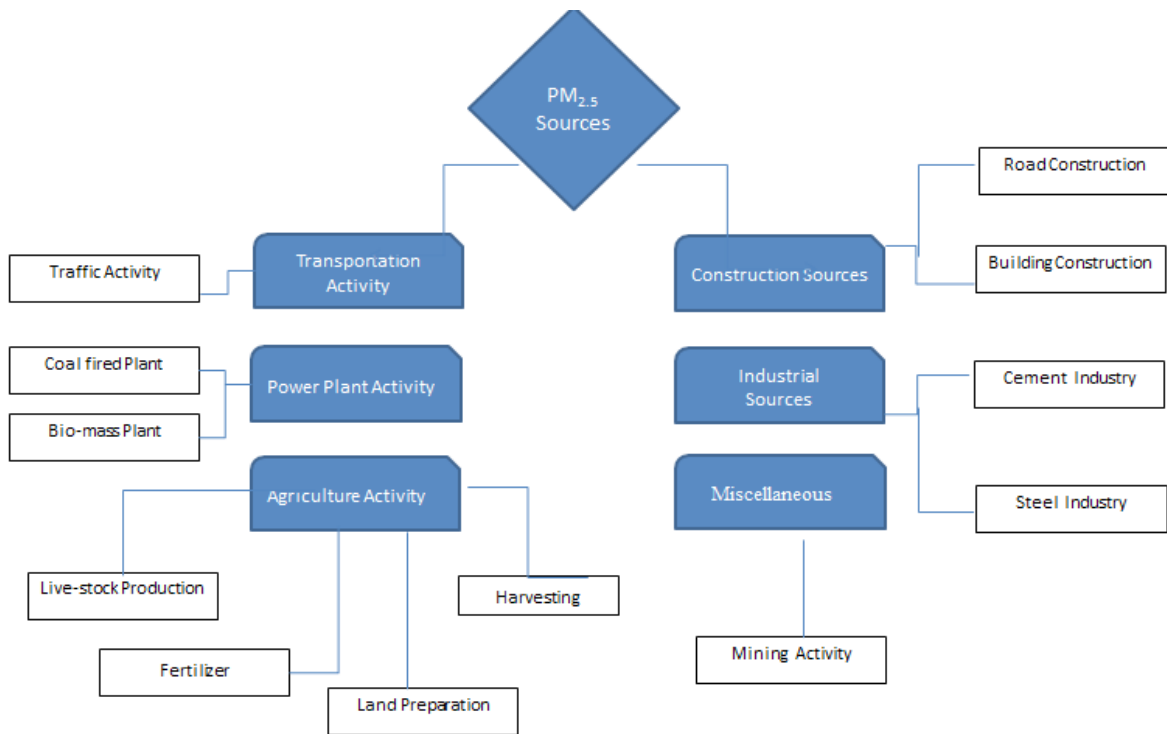


Fig. 1. Major sources of $PM_{2.5}$ (Chen, *et al.*, 2017).

illnesses exacerbated by breathing dirty air, according to the World Bank in 1999. It affects people about 6 times more than malaria and almost 4 times than HIV. Air exposure is also attributed to one-third death rate is related to strokes, chronic respiratory conditions and lung cancer. Furthermore, the WHO estimates that about 90% population in the poor and middle-income countries may not have access to clean air (World Bank, 2016). According to World Bank, particulate matter causes 700 deaths among children and 22,000 premature mortality rates among adults in Pakistan each year, accounting for 1% of the country's GDP. Bombay, Calcutta, and Tehran were found to be the most polluted cities in Asia, according to a World Health Organization survey (WHO). In Asia according to WHO premature death rate each year is approximately 360,000 due to urban air pollution (Colbeck, *et al.*, 2009). Similarly, Faisalabad is classified as a highly polluted city of Pakistan. The city's climate is deteriorating day by day as a result of accelerated industrialization, commercial zone development, and rapid urbanization (Wippich, *et al.*, 2020). Many studies found a relation between respiratory illnesses and cardiovascular diseases and PM₁₀. While some studies that human health is majorly affected by finer particle which is supported by the evidence human respiratory system is adversely affected PM_{2.5} (Guevara, 2016). However, studies revealed that in Pakistan highest premature deaths rate is 105 thousand per annum caused by increased levels of PM_{2.5} (Aslam, *et al.*, 2020). The PM_{2.5} particles are responsible to reduce the visibility in air along with various health issues. It has been found that increasing PM_{2.5} concentration would

lead to certain susceptible diseases in peoples, including asthma, acute respiratory symptoms, lung cancer, myocardial infarction and mortality (Adams, *et al.*, 2015). Much of the PM historically arose from the burning of coal and was measured as black smoke. Different pollutants have adverse effect on human health such high concentration of CO in the air, when inhaled by human cause a reduction of the ability of circulating system to transport oxygen leading to cardiovascular diseases, NO_x can cause respiratory problems, O₃ can cause coughing, severe decrement in pulmonary function, chest discomfort high rate of increase in asthma attacks, SO_x increase risk of respiratory diseases¹⁰. PM has become a severe issue due to its noticeable adverse effect on human life. There have seen a strong relationship among air pollutants and observed health effect on human health by various studies conducted by various authors. Strong evidence is present that indicate that fine particles (dp < 2.5 μm) play a key role in effecting human health (Guevara, 2016) and can be deposited on the upper walls of bronchi. Particle behavior in the lungs always depends upon the aerodynamic feature of particles in flow stream that are related to shape, size and density. Particles deposition in various part of the respiratory system depends on their size such as nasal can allow larger particles to enter in respiratory system. The major source of air pollution in Pakistan, according to the previous studies was due to vehicular emissions from industry, thermal power generation, biomass burning, and trans boundary. The percent of emissions generated from these pollution sources are explained in Table 2 below (Aslam, *et al.*, 2020).

Table 1. Types and sizes of particulate Matter (PM₅)

Type		PM diameter [μm]
Particulate contaminants	Smog	
	Soot	0.01–1
	Tobacco smoke	0.01–0.8
	Fly ash	0.01–1
	Cement Dust	1–1008–100
Biological Contaminants	Bacteria and bacterial spores	0.7–10
	Viruses	0.01–1
	Fungi and molds	2–12
Types of Dust	Allergens (dogs, cats, pollen, household dust)	0.1–100
	Atmospheric dust	0.01–1
	Heavy dust	100–1000
	Settling dust	1–100
Gases	Different gaseous contaminants	0.0001–0.01

Strategies to Control PM Concentration

Pollution reduction and carbon control policies will help to reduce airborne particulate matter (PM) emissions. Prevention should be prioritized over regulation because it is also more cost-effective. Table 3 shows the automation technologies that are used to control PM ¹².

Management

Emissions can be reduced by better process planning, service, cleaning, housekeeping, and other management activities. By improving combustion efficiency volume of incomplete combustion products (PICs), a factor of particulate matters, can be substantially decreased. Lower PICs can be achieved with proper fuel-firing procedures and combustion zone setup, as well as an adequate volume of excess air (Anjum, *et al.*, 2021).

Choice of Fuel

Cleaner fuels can limit particulate pollution in the atmosphere. Natural gas emits very little particulate matter when used as a fuel. In addition, compared to coal-fired burning, oil-based processes produce

considerably less particulates. Low-ash fossil fuels have less noncombustible, ash-forming mineral content, resulting in lower particulate emissions. Particulate emissions from lighter distillate oil combustion are lower than those from heavy residual oils. However, the fuel alternative is usually affected by both environmental as well as economic factors (Anjum, *et al.*, 2021).

Fuel Cleaning Process

The generation of PM emissions is reduced as ash is reduced by fuel cleaning. Co-firing coal with higher and lower ash content is an alternative to coal washing. PIC pollution can be reduced by using more efficient systems or changing the way things are done. Advanced coal combustion technologies like coal fluidized-bed combustion and gasification are examples of safer processes that can reduce PICs by up to 10%. PM emissions are reduced in enclosed coal crushers and grinders (Anjum, *et al.*, 2021).

Individual Strategies and Technologies

Specific management strategies aimed at improving air quality are examined here, along with the data supporting their efficacy.

Table 2. Emissions (Gg)/yr of pollutant sources such as of SO₂, NO_x, CO, NMVOCs, BC, and OC from different sectors of Pakistan (Rai, 2016).

Species	Power(Gg)	Industry (Gg)	Residential(Gg)	Transportation (Gg)
NO _x	13.50%	39.60%	3.00%	43.20%
CO	0%	3.70%	62.90%	23.50%
NMVOCs	0.10%	16.50%	43.30%	39.90%
SO ₂	14.60%	75.60%	2.40%	7.30%
BC	0.60%	31.60%	58.70%	8.70%
OC	1.70%	0.80%	96.30%	2.60%

Table 3.

Source of PM	Strategies as Well as Technologies to Control PM
Transportation activity	(Upstream control) Catalytic converter, Regulating precursor pollutants preset in raw material, Lubricant consumption, Reduction in motorized transportation demand, Road quality and traffic flow.
Agriculture activity	Livestock feeding, Animal housing system, Manure storage, manure used for crops and fertilizer applications.
Construction activity	Controlling Site planning, Construction traffic, Demolition traffic and Site activities.
Miscellaneous	Controlled mining and plant activities.
Industrial and plant activities	(Downstream control) Incinerators, Electrostatic Precipitators (ESPs), Bio filters, Cyclone Separators, Gravitational settling chambers, Wet scrubbers and fabric filtration, Inertial or impingement separators.
Improving Air Quality: Strategies Technologies	Individual Strategies and Technologies Private Vehicle, Outreach Strategies, Behavioral Change, Speed Management, Low Emission Zones. Removing Pollutants from the Air, Trees and Vegetation, Switching to Less Polluting Cars Roadside Barriers, Monitoring Air Quality

Strategies

The number of evidence-based air quality policies concentrate on reducing private car use. This is mostly accomplished by rules and laws, as well as investments in infrastructure that encourages alternate modes of transportation. Here, we'll go over the important air quality measures and include examples of how they've been implemented (Popoola, *et al.*, 2018).

Private Vehicle Behavioral Change

Methods for discouraging private vehicle usage are often combined with policies to make less polluting modes of transportation, such as walking and mass transportation, more attractive in urban air quality policy combinations. Public transportation must be regular, efficient, reasonably fast, and theoretically subsidized in order to be a feasible choice. Several countries are now exploring how to make it easier for people to switch between modes of transportation. Singapore intends to build more interconnected transportation centers, allowing for smoother transitions between modes of transportation, such as from bus to rail. In Port Talbot, an interconnected hub connecting bus, rail, and cycling facilities has opened. Cycling is one of the least polluting ways of transportation, and it, along with walking, is classified as active commuting. Despite this, there is a paucity of data quantifying the effects of cycling on air quality, as most traffic-related air quality analysis focuses on pollutant pollution. For example, 40% car trips reduction in Barcelona City will result in a reduction of PM_{2.5} concentrations 0.64 percent and reduce 10.03 air pollution-related deaths every year. They also discovered that the advantage of decreased air emissions to the general public is much less than the benefit of increased physical exercise that cycling provides, as stated in. Bicycle and car share programmes are both promising ways to improve quality of air, and they can be supported by technologies, such as car club applications. They may also be aided by legislation or policy. Employers in San Francisco, for example, are expected to allow workers to cycle, carpool, or use public transportation by including pre-tax deductions for transportation costs (Popoola, *et al.*, 2018).

Speed Management

Lower speed limits are used in many European

countries which reduces emissions by reducing the stop-start nature of traffic rather than by reducing the speed of the cars and thereby avoiding excessive acceleration and deceleration. Emissions caused by brake and tires wear, as stopping from 20 mph releases volume of particulate matter about half than stopping at 60 MPH. Impact of speed control measures is determined by local weather patterns as well as the physical facilities surrounding the lane (Popoola, *et al.*, 2018).

Outreach Strategies

When combined with other air quality programmes, outreach and promotion campaigns have been seen to raise public visibility and compliance. Singapore's air quality policy, for example, places a strong focus on community governance of air pollution related issues and maintains annual "community and youth for the atmosphere" days. Green champions were recruited by the Royal Borough of Kensington and Chelsea to teach residents on energy conservation and waste reduction. Involving industry, academia, and non-governmental organizations (NGOs) in the design and implementation of programmes improves compliance, and can be promoted by award systems like the "City of London Corporation's" awards for businesses that use renewable technologies. In the other hand, rather than state or national governments, citizens themselves may be the driving force behind environmental ownership. People in Birmingham's Kings Heath suburb teamed up with the consulting company Earth sense in 2017 to track local emissions levels and organize a "Clean Air Day" where inhabitants were urged to drive via active means of transportation rather than driving (Popoola, *et al.*, 2018).

Technologies

Pollutants Removal from the Air

Because of their unusual designs, technologies intended to eliminate emissions from the air often attract public interest. For example, in Xi'an, China recently completed a 100-meter-high air purification tower that look like a chimney and use greenhouses to transport air through a filtration device. However, there is no evidence to back up the tower's initial performance claims. Separately, several countries, including Japan, Netherlands, and England, have tested compounds that have capability to absorb NO₂ from the air. These may be painted on surfaces

or embedded in materials like roofing felt and pavement slabs. Outcomes of these measures are also inconclusive, and their efficacy can be harmed by daily wear and tear. Water cannons were also recently tested in Delhi to wash contaminants from the air, but they had no discernible impact. There are a variety of solutions available to make diesel and gasoline vehicles less polluting. For decades, catalytic converters, which reduce unhealthy tailpipe emissions, have been a legal necessity for new cars in the United Kingdom and several other countries around the world. Shell has produced a synthetic diesel “drop-in” replacement that needs no engine modifications. This could reduce NO_x and PM emissions, but it is yet to be thoroughly tested. San Paulo, on the other hand, has concentrated on “flex” engines, which can run on a variety of fuels, typically a mix of gasoline and ethanol. Hybrid cars, on the other hand, are usually powered by both electric and internal combustion engines. While there is some evidence that ethanol-based flex vehicles emit less NO_x than gasoline or diesel-powered vehicles, the particular background in Brazil, including the country’s investment in ethanol production facilities, could make flex vehicles a less feasible initiative elsewhere. Another common tactic is to persuade people to replace older, more polluting cars with newer, healthier models, which is mostly accomplished by a combination of taxes, discounts, and financing. Electric vehicles are the most well-known environmentally friendly vehicles, and their share of the global automotive fleet is growing. Electric car use cuts through the policies and solutions divide, so this emerging technology will only improve air quality if people change their purchasing habits and start using them. In the long run, there is a push for electric cars to become self-driving, i.e., without the need for a person to operate them. Autonomous vehicles can improve air quality by reducing the human propensity for stop-start driving and braking, as well as by vehicle platooning, which involves a group of vehicles travelling closely together to improve aerodynamics. The disadvantage of the growing number of electric cars is that, if they continue to rise at their current rate, government revenue from fuel taxes will be limited (Popoola *et al.*, 2018).

Roadside Barriers

Roadside noise control barriers, including congestion charging zones, have an effect on air quality despite not being designed to do so.

Artificial barriers are considered as a promising air quality measure because they help to reduce noise behind them. Barriers made up of a combination of vegetation and artificial material seem to have the best effect on air quality, while barriers made entirely of vegetation with dense foliage are also promising (Popoola, *et al.*, 2018).

Trees and Vegetation

Perhaps counter intuitively, plant barriers may be useful in blocking waste movement for the same purpose. Their canopies will function as a roof, stopping waste from dissipating if they are planted along major roads. However, in less densely populated areas, they can also be an important means of enhancing air quality, since their leaves are capable of filtering out such toxins such as NO₂. Morani *et al.*, “planting ‘s preference index” map, which rates areas according to localised emissions levels, population density, and current tree cover, has been developed as a guide to where to plant trees for optimum air quality value. Conifers have been shown to absorb more carbon than broad-leaved trees, according to studies into the most successful tree species for enhancing air quality. Initiatives centered on tree planting, such as New York’s “Million Tree Initiative,” can thus be helpful, but they should not be seen as a panacea for air pollution problems. There is some evidence that “urban greening” measures such as green walls and vertical gardens, which have the ability to contain NO₂ and particulate matter, can improve air quality. Many cities around the world are experimenting with urban greening, like Sydney, Singapore, and Mexico City. There is some evidence that “urban greening” measures such as green walls and vertical gardens, which have the ability to contain NO₂ and particulate matter, can improve air quality. Many cities around the world are experimenting with urban greening, like Sydney, Singapore, and Mexico City (Popoola *et al.*, 2018).

Air Quality Monitoring

Knowing both the average rate of air emissions and the chemical makeup of the pollution is important for selecting the most appropriate air quality measures. However, most countries lack a systemic approach to air quality control. As a consequence, there is a scarcity of air quality evidence, making it difficult to assess the efficacy of air quality policies. The need to extend and strengthen surveillance networks is repeatedly mentioned in the literature as

a necessary condition for bettering air quality. The following are few examples. In addition to the EU-funded CITI-sense network and citizen-led surveillance described above, the Chinese government has created a national network monitoring PM_{2.5} levels, the data from which is freely accessible and can be reviewed in real time by anybody with a smartphone, similar to England's "London Air" app. The opportunity for air quality control is linked to a greater interest in smart cities, which refers to the various and varied ways that technology can be integrated into everyday urban life to enhance it 9. To limit PM emissions, both of the above techniques are employed (Popoola *et al.*, 2018).

Control of Transportation Activity to Reduce PM

Strategies to control or reduce air pollutants emitted as a result of various transportation activities include the application of catalytic converters, regulation of precursor pollutants in raw material, control of lubricant consumption, improvement in road quality and traffic flow and reduction of motorized transportation demand.

Catalytic Converter

A vehicle emission control device is termed as catalytic converter. Its function is to convert toxic pollutants in exhaust gas in less toxic pollutants by oxidation reduction reactions. Generally, a catalytic converter is used in internal combustion engine, consists of three major parts that are; substrate, washcoat and catalytic mate. Substrate material is typically a ceramic monolith with a honeycomb structure. Washcoat is usually, silicon dioxide, aluminum oxide, titanium oxide or a mixture of alumina and silica is used as a catalytic material that is often mixed with precious metals such as palladium, rhodium and platinum. It has the ability to reduce NO_x into N₂, oxidize or combine CO (carbon monoxide) with/ or unburned HC (Hydrocarbons) to form CO₂ and H₂O. In downstream engine, at optimal condition, a catalyst application can reduce 70-90% NO_x emission from vehicles (Niaz *et al.*, 2016).

Raw Materials

Based on regulations, air pollution can be control by controlling the precursor pollutant present in raw material such as lead and sulfur. Oxides of sulfur (SO_x) are formed as result of combustion of fossil fuels such as diesel and gasoline. So by shifting

towards low-sulfur-content fuels is considered a good strategy to reduce the emissions of SO₂. Shifting towards new generation fuels such as natural gas as well as biofuels for transportation can also help to reduce SO_x emission due to environment friendly nature of both fuels (Manisalidis *et al.*, 2020).

Lubricant Consumption

Lubricants formed by a base fluid and additives. Major part of the lubricant formulation is base fluid and is made from petroleum-based oils. Desirable properties are obtained by using additives. Lubricants are key substances that are used to reduce wear and tear of machine parts as well as friction that in turns minimize heat loss. Global lubricant consumption is more than 41 million tones. They have 60% of soluble organic fraction contributing 20% and 90% of the total particulates in air generated from engine lubricant consumption. So PM emission rate can be minimizing by minimizing the engine lubricant consumption. Using bio lubricants (eco-friendly, biodegradable lubricant, recyclable, reusable and nontoxic) is also prove to be a good strategy to reduce the hazardous effects of traditional pollutants of lubricant engines (Jimoda, ??????).

Control of Agricultural Activities

Methane (CH₄), nitrous oxide (N₂O), and ammonia (NH₃) are the most common air contaminants released by agriculture .Agriculture is another significant source of PM, both primary and secondary. Livestock processing and the use of fertilizers and chemicals are the primary sources of agricultural contaminants. As a result, methods to manage air contaminants released by agricultural operations are inextricably related to activities such as livestock feeding, animal housing systems, manure management systems, manure application to crops, and fertilizers and pesticide application (Shahid *et al.*, 2015).

Livestock Feeding

The amount of nitrogen compounds excreted in animal waste and urine is largely determined by the amount of nitrogen consumed in food (protein), the measures that are taken to reduce the nitrogen excretions in animals by controlling protein in their feedstock that ultimately lead to decrease emissions of nitrogen-containing compounds. Such strategies involve providing the animal's amount of proteins in

their food on the basis of their needs. On average, 1% reduction of protein in animal feedstock leads to 10 % reduction of NH₃ emission. Reduction of protein does not affect animal health as long as they meet all the requirements of amino acid. This strategy is applicable on housed animals while the practical applicability of feeding strategies to grazing animals is limited (Shahid *et al.*, 2015).

Animal Housing Systems

The available strategies are used to reduce NH₃ emissions from animal housing systems have been well known for decades and include that include removal and separation of urine and feces up to 25-46%, decrease of temperature 60% and pH 20% of manure, drying of manure 45-75%, scrubbing of ammonia 60% from exhaust air and increased grazing timing by decreasing housing time 75-95% (Shahid *et al.*, 2015).

Manure Storage

The following guidelines should be used to develop methods to reduce air contaminants released by manure storage: Reducing the surface area where pollutants will occur by covering the storage, encouraging crusting, and increasing the storage depth. Reducing the pH and temperature of the manure by covering the storage, encouraging crusting, and raising the storage depth. Distractions such as aeration are minimized (Shahid *et al.*, 2015).

Manure Used for Crops

Manure application for crops can produce a large amount of contaminants in the atmosphere. The following criteria should be used to develop methods or implementation approaches to manage emissions:

- Using band application, injection, and incorporation, reduce the exposed surface area of slurries applied to surface soil. Reduce the source intensity of the leaking surface by reducing the pH and NH₄ content of the manure (by dilution)
- Reduce the time that emissions can occur by burying the slurry or solid manures by injection or incorporation into the soil (Shahid *et al.*, 2015).

Fertilizer Application

The techniques for reducing pollutant emissions from fertilizer application are based on one or more criteria, including: Reduce pollution sites by reducing surface area by banding, injection, and integration. Reduce pollutant emission cycles by

incorporating fertilizers quickly into the soil or irrigation. Use urea inhibitors and mixing to reduce the surface intensity of the emitting source. Use of pollutant precursors such as ammonium (bi) carbonate should be prohibited. For example, the following strategies for applying urea and ammonium-based fertilizers can minimize ammonia emissions (Shahid *et al.*, 2015).

Control Construction Fields

Regulation of site preparation, construction traffic, demolition works, and excavation practices are the four types of techniques for controlling air pollution released from construction sites (Shahid *et al.*, 2015).

Site Planning

Erect appropriate walls around dusty operations or around the entire site perimeter to monitor air pollution released from site planning. During the entire site preparation process, no materials can be burned. All site workers must be professionally qualified. During operating hours, a trained and conscientious manager is on hand to monitor the logbook and conduct site inspections. Use local rail or wetlands for transportation to/from the site (e.g., use recycled rubber blocks, concrete blocks, or tarmac) Hard surface all main haul routes across the site (e.g., use recycled rubber blocks, concrete blocks, or tarmac) (Shahid, *et al.*, 2015)

Construction Traffic

No trucks or plants can be left idling unnecessarily, according to regulations in place to regulate pollution emissions released by building traffic operations. Before leaving the premises, wash or scrub all vehicles thoroughly. Building traffic should be kept to a minimum while the pavement is cleaned on a regular basis, and speed limits should be enforced appropriately around the site. For all non-road mobile machineries, ultra-low sulphur tax-exempt diesel is used to meet pollution requirements (Shahid *et al.*, 2015).

Demolition Projects

Regulations that are opted to reduce emission of pollution from demolition works by wrapping buildings, using water as dust suppressant, removing damp or debris, and Bags before demolition and whenever possible stop using explosives and instead try using suitable manual or mechanical alternatives (Shahid *et al.*, 2015).

Site Activities

Regulations enacted to reduce dust-producing practices and thereby regulate air pollution released from operation sites. When a worker uses a power tool to cut concrete slabs or bricks without extracting or suppressing the dust, a second worker may spray the water over the material, reducing the number of dust particle produced. Wherever possible, use water as a dust suppressant. Where necessary, ensure the concrete crusher or concrete batcher has a permit to function by covering, seeding, or fencing stockpiles to avoid wind whipping. Re-vegetate earthworks and unprotected fields (Shahid *et al.*, 2015).

Reduce Motorized Transportations Demand

Strategies, encouraging the utilization of non-motorized transport as well as discouraging the use of private cars, shortens trip lengths and lessens non-essential trips can minimize the overall demand of motorized transport thus eliminating or reducing the air pollutants caused to due to transport activity.

Road Quality and Traffic Control

Air pollutants emitted as a result of transportation activity are directly affected by road quality. For example, transport vehicles operating on unpaved roads can emit a significant amount of PM into the atmosphere; therefore, improving road conditions can reduce air pollutant emissions. Paving unpaved highways, flushing roads with water during the dry season, and researching alternative types of asphalt and concrete that are environmentally safe and inexpensive will also help to increase road quality.

Controlling Industrial and Plant Activities

Sometimes industrial and plant activities can prove important source of PM due to its activity and smaller as well as larger scale production of particular goods and electricity etc.

Impingement or Inertial Separators

In inertial or impingement separators inertial properties of the particles are used to separate them from the carrier gas stream. Inertial separators are most often used to collect medium- and coarse-sized particles. There are settling chambers and centrifugal cyclones among them (straight-through, or the more frequently used reverse-flow cyclones). Cyclones usually have a fine-dust removal efficiency of less than 70%, while electrostatic precipitators (ESPs) and bag houses may have removal

efficiencies of 99.9% or higher. Cyclones are cost-effective, low-maintenance centrifugal collectors that are often used to filter particulates that are 10–100 microns (mm) in scale. Cyclones are often used as a first step in the removal of PM. They usually cost about \$35 (m³/min) or \$1 (cu. ft/min) (Anjum, *et al.*, 2021).

Incinerators

Incinerators are used for waste treatment processes involving the combustion of organic substances present in waste material also termed as thermal treatment. Nowadays, modern incinerators are equipped with an efficient system for the reduction of pollutants and PM emissions. The PM reduction using incineration technologies are experimentally proved to be very efficient. The PM removal efficiency proved to be more than 99.99% (Anjum *et al.*, 2021).

Electrostatic Precipitators

The Electrostatic precipitator (ESP) or electro-filtration is the devices used for controlling particulate emissions most effectively and widely at different installations ranging from power plant, oil refineries pulp and paper mills to cement factories. They can also be used in theatres, public buildings, cars, railway, etc. for the purpose of cleaning air. Particles are charged electrically and are attracted to collector surfaces (The World Bank, 1999). This is an efficient device mostly used for eliminating fly ash particle from flue gases generated by coal-fired boilers used in power plants for electricity generation But due to its fractional collection efficiency that steeply reduce for particles smaller than 1 mm as well as particles ranging in size 200–500 nm are eliminated with lower collection efficiency as compared to those outside this range. Such particles are hazardous to human health and also cause detrimental environmental effect. This problem is reduced by using two-stage electrostatic precipitators. In this type of technology electrostatic charging and precipitation processes have been separated. Particles (PM) of a size < 2.5 mm are electrically charged in a separate device so high electric field trigger the removal of more amount of PM as compared with conventional electrostatic precipitators (Popoola *et al.*, 2018). ESP can either be single-stage or two-stage in design. ESP can be categorized, into wet precipitators and dry precipitators depending upon the type of process (The World Bank, 1999).

Biofilters

Biofilters are being used mechanically ventilation livestock building for treating the ventilation air. Normally wood chips are used to create a bed of biological material and ventilation air flows through the material. Cultures of microbes that develop within the bed absorb gasses. In biofilters media, moisture content (>40%) is critical for keeping cultures to maintain its effectiveness so in order to overcome this problem sprinklers and other wetting systems must be used. PM is removed via physical impaction but might stop air flow in dusty environment because it gathers within the biofilters. Biofilters can be used for PM reduction but as it has a lot of precautions and measures also difficult to design so it is not as widely used as other technologies (Niaz *et al.*, 2016).

Scrubbers

Scrubbers is a device use to control particulate matter from gas stream and scrubbers are economically suitable then other particulate matter control device. Turbulent wet scrubber removes PM emission in gas stream of industrial power plant of coal at micro and sub micro meter level. Turbulent wet scrubbers may have ability to remove 95 to 99% of PM size ranging from 0.1 to 100 μm in bubble column scrubber. Advance level of turbulent wet scrubbers may have tendency to remove 100% particulate matter (Jimoda, ??????).

Fabric filter

Fabric filters are also called dust collector or bag houses this is a device used to control particulate matter from gaseous and liquid phase before emitted in the atmosphere. They also help in removing solid particles from waste disposal so recycling of water may easily do. In fabric filters solid particles may stick to the fabric and clean air pass exposed to the atmosphere. Fabric filter achieve efficiency of sub micrometers to micrometers level [16]. Respiratory common cloth mask is also a good example of fabric filters used for aerosols particulate matter which have filtration efficiency range from 10nm to 10 μm . Multi layered cloth mask have high filtration efficiency against aerosols particles. The results of above discussion is that the use of different combination of fabric (cotton, silk, chiffon, synthetic fiber etc.) have different filtration efficiency with respect to size ranges (The World Bank, 1999).

Cyclone Separators

We all know that burning of coal produce energy and left a large quantity of residue which is known as particulate matter and particulate matter is removed by different techniques in which one of them is cyclone separators which is also called dry scrubbers. Cyclone separators work on the principals of inertia. They have certain limitations they used for the removal of large particles of particulate matter. Due to centrifugal force particles may suspended are segregated in gaseous phase and large particles move inside the cyclone due to the principal of inertia. Particle size and density decides the efficiency of cyclone. In many industries cyclones are still used because of its simple cone like structure with no moving parts, low cost and resist high pressure and temperature.

Settling Chambers

Settling chamber is a device working on the basis of gravity used to control or remove the amount of particles present in atmosphere or simply particulate matter in this device due to gravity solid particles in the emissions settled down to the bottom of chamber. Settling chamber are of different types the most common used for dust particles are rectangular type in which trays are fixed (Bradley, ??????). Settling chamber is such a device used for hard or large particles. If there are no baffles in the settling chamber then 100 μm or particles greater than 100 μm will remove with 50% efficiencies. Percent of efficiency increase with the arrangement of baffles present in chamber. At 30 angles tilted flat baffle show 75% efficiency with particle size larger than 50 μm and the efficiency may 100% when vertical baffle present in the center of settling chamber (Jain and Suhane, 2013).

CONCLUSION

Examining Particulate matter with diameters less than 10 μm to 2.5 μm has gained scientific attention due to its environmental pollution effects owing to its adverse effects on human health. In this article, we looked at PM_{10} and $\text{PM}_{2.5}$ and found that, as a result of expanding industries, air quality has become a significant problem, resulting in elevated risk factors for chronic respiratory diseases. Carbonaceous aerosols are also found in higher concentrations in the air, according to our findings in the Faisalabad city a major industrial hub of textile

and chemical industries of Pakistan as compared to other major cities like Islamabad, Lahore and Peshawar. The air quality varies from low to heavily contaminated, making it extremely hazardous to human health. We have concluded that although PM has a severe impact on human health as well as on our environment yet it is possible to control the range of emissions by practicing various technologies mentioned above.

Recommendation

There is need of a concerted effort to implement effective emission prevention and management strategies, such as plantations and green belts, in order to improve quality of life. Reducing emissions by replacing high-energy-consuming sectors with green and clean energy sources, as well as other policies that reduce the usage of fossil energy, will be a long-term approach to increase air quality. Wavelet analysis may be used in future experiments to analyze the temporal features of $PM_{2.5}$ and PM_{10} , as well as the association between meteorological influences and PM_{10} .

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