Chapter 2
Atmospheric Emissions from Construction Sector

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Abstract Atmospheric pollution created by the construction industry has both direct and indirect effects on the general environment. The proper assessment and mitigation of the burdens of the environment from construction activities is the need of the hour. There must be a comprehensive evaluation of the impacts that need to be taken care of at all the construction activities. During construction, direct atmospheric gaseous emission, emission of particulate matter and other trace gases are released by the machineries and equipments, which have serious environmental impacts that affect the local air quality to a greater extent. As a result of these atmospheric emissions, the flora and fauna of the area do not grow well, causing significant loss to biodiversity and disruption of the food chain. Further, the various types of equipment used in the construction sector are particularly very noisy, which can cause people living near construction sites to experience varied levels of health disturbances. The construction sector should also share the responsibility of monitoring and limiting the quantity and quality of pollution it collectively generates. Thus, the development projects must be prepared in such a way that it has reduced minimum negative impacts on the environment.

Keywords Atmosphere · Construction · Developmental projects · Green · Monitoring

2.1 Introduction

The contribution of construction sector to the total direct and indirect global greenhouse gas (GHG) emissions in 2010 was 18% (IPCC 2014), and it was also the biggest user of materials in 2005 having direct impacts on the utilization of use and greenhouse gas emissions (Krausmann et al. 2009). Among different important atmospheric gases emitting sectors, there are greater abatement opportunities to a greater extent for reduction of emission in the construction sector and the sector offers large opportunities in the short-term due to its cost importance and relationship with GHG

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emissions by different chains in construction supply (Giesekam et al. 2015). As a matter of fact, construction sectors are bigger contributors to atmospheric pollution; sectors within the industry have a common responsibility for reducing the amount of waste they produce. In fact, the majority of the policies, acts and regulations mainly focus on decreasing direct atmospheric emissions from the construction sector, in recent years the basic research has paid greater attention to the life-cycle of GHG emissions into the atmosphere of the construction sector (European Commission 2014). The latest review of life-cycle energy use in construction sector reported that embodied energy is between 5 and 100% of total life-cycle energy utilization (equal to 10–97% of total life-cycle emission of carbon emissions) dependent on functions of building, place, use of materials and tentative assumptions regarding the life service and energy usage. These proportions increase as construction changes from conventional to modern, less energy and nearly zero energy constructed buildings (Chastas et al. 2016). Acquaye and Duffy (2010) researched that about 11.7% of national emissions of Ireland in 2005 were from the construction industry, and 71% of emissions were from indirect sources. Meanwhile, the construction industry in Norway produced GHG emissions of 4.2 metric tonnes and 5.3 metric tonnes of CO_2 in 2003 and 2007, respectively, with embodied atmospheric emissions accounting for the majority of total atmospheric emissions (Huang and Bohne 2012). The use of energy in the construction industry was nearly about 50% of total energy use in China in 2007 and the largest contributors to embodied energy use in construction were products for construction, warming, fossil fuels and electricity (Chang et al. 2010). Chen et al. (2017) also found that the construction sector is contributing to about 66.5% of total carbon emissions of China and was the biggest carbon producer of all other industries in 2009 in China, out of which indirect (embodied) carbon emissions were 96.6% with the highest contribution from electricity, water and gas supply sector. Further research studies of Ireland's and Norway's construction sector emissions, as well as others, identified related future areas for emission control across various phases, including increasing the percentage of reusable energy, increasing machinery and equipment maintenance, minimising operations, reducing the amount of carbon-using substances needed, and reducing the distance for transportation (Acquaye and Duffy 2010; Chang et al. 2010).

Atmospheric emissions at the construction sector are produced from activities related to the construction phase of a project. The various construction activities are typically very short-term or temporary in duration. The construction activities includes various types of operation of large on-road and off-road instruments for soil disturbance or hauling of soil and delivery of materials, moving, piling of the construction materials, piles with open storage and both inactive and active disturbed land areas. The emissions of atmospheric pollutants and GHG into the atmosphere may be because of the result of the mentioned onsite activities. Moreover the emission from construction of a project may have a significant effect with regard to atmospheric air quality and global climate change. Fugitive dust along with engine combustion emissions is generated with the usage of large equipment and soil moving operations at construction of buildings that can have substantial temporary effects on regional air quality. PM with a diameter size that is less than ten microns in size

may also have their origin from fugitive dust including open fields, roadways, piles of storage, soil work, etc. The various sources of fugitive dust emissions includes building demolition, soil excavation, land clearing, fill and cut operations and use of traffic equipment on roads that are temporary at construction sites. As a matter of fact most of the construction machines use diesel fuelled engines. Exhaust from diesel engines is the source of emission that is having a significant impact on human well-being and health. CARB (California Air Resources Board) in July 1999 listed diesel particulate matter (DPM) at construction sites as a very toxic air contaminant, having both chronic and carcinogenic human health risks. DPM in addition to diesel exhaust also includes atmospheric emissions of certain other pollutants e.g., NOx and ROG (reactive organic gases like benzene and carbon monoxide) as well as GHG. Atmospheric emissions from the construction sector are mostly produced with the use of huge, diesel-fuelled scrapers, excavators, heavy loaders, bulldozers, haul trucks, large compressors, diesel fuelled generators and other large equipment. Atmospheric emissions at construction sector from both fugitive dust and from combustion sources may vary to a greater degree daily depending on the level and nature of activity, the type of operation, use of dust reducers, moisture content of soil, and onsite prevailing weather conditions.

As the construction sector is showing rise in growth, it will have a deleterious effect on the environment. As per the U.K. Green Building Council, about 400 million tons of materials a year are utilised by the construction industry and most of them can have varied adverse implications on the environment. More ever the materials used during various construction activities can also have a negative impact on the surrounding environment because of the extraction of raw materials. According to the Environmental Protection Agency (EPA 2008), in the United States, a number of equipment and materials daily used by construction workers and building firms, such as various chemicals onsite can significantly be harmful to public health and to the environment. Furthermore, the United States construction industry is accounting for about 160 million tons (25%) wastes other than industrial wastes generated a year. In another research by United States Green Building Council (USGBC), the construction industry uses 40% of energy worldwide, with estimates that the atmospheric emissions from building of commercial value will raise by 1.8% by 2030. According to the Environmental Protection Agency, construction activity can change the land surface mainly because of vegetation clearing and excavating. According to the EPA, this means that surrounding environments of the construction site can be heavily polluted, which may experience a rise in atmospheric pollution. As per Kleiwerks International the construction material from construction sector like cement, sand, concrete, aluminium and steel, are responsible for huge quantities of CO_2 emission because of higher concentration of "embodied energy content", having 9.8 mt (million tons) of gaseous CO_2 created from the creation of 76 million tons of finished concrete in the US. This research further adds that the current practices of the construction industry at reducing atmospheric emissions are greatly non-effective and may even produce higher levels of greenhouse gas pollution. It further says that the construction sector activities utilize various types of materials from nature and the construction sector accounts for one-sixth of world freshwater consumption,

one-fourth of wood use, and generates one-fourth of global waste. However, Environmental Protection Agency's regulations are clear and the rules say that at the outset of any construction project the protection of the environment should be first priority.

Global warming is the result of increasing average atmospheric temperature, and drives a lot of changes to the globe's weather systems and climate. Heat-trapping greenhouse gases (GHG) are emitted in the atmosphere as a result of swift changes by humans in the atmosphere (Alhorr et al. 2014). Among atmospheric emissions, emission of carbon dioxide (CO_2) into the atmosphere is the important man-made greenhouse gas because of its increased concentration in the atmosphere and its property to remain in the air for a longer period of time (Riffat and Mardiana 2015). CO_2 emission in the atmosphere is both from natural and anthropogenic sources. Urbanization process is one of the main sources of CO_2 production. Urbanization in real terms is a continuous process that converts rural places into urban places with a large number of persons in urban areas and the increase of the built environment both vertically and horizontally. In urban cities, the built environment refers to the developed surroundings that create infrastructure and different services for human society, and the built environment is one of the most important components of a country's socioeconomic growth. Therefore, the increased urbanization has played a pivotal role in production CO_2 emissions in the construction sector.

The building sector in general is from construction to operation that may be again divided into two components; residential buildings and non-residential buildings. The construction sector includes the processes of making structures in areas of a place and the operation, maintenance and service of the constructed object. With the construction sector showing growth in development, a major direct and indirect effect of the construction sector on the environment has been seen. It is also taken as one of the important utilizing and waste producing portions of the economy (Bilal et al. 2020). Various environmental impacts of the construction sector can be differentiated into ecosystem impacts, people impacts and natural resource impacts (Zolfagharian et al. 2012). The building sector also consumes significant energy and production of atmospheric emission, for example GHG emissions, PM, oxides of sulfur, carbon monoxide, and oxides of nitrogen (Sandanayake et al. 2019). Due to energy consumption by the building sector, the ambient CO_2 level has increased (Adams and Nsiah 2019; Chang et al. 2019). The major sources of CO_2 emissions into the atmosphere by the construction sector is from the energy consumption that is needed for the manufacturing and transportation of different construction materials to the processing of different resources, building waste disposal, and the need for construction equipment (Yan et al. 2010). The building sector also utilizes a major percentage of energy that is non-renewable and that results in generation of a huge concentration of CO_2 in the atmosphere (Huang et al. 2018). Building sector contributes to about 39% of the global annual CO_2 (IEA 2019) (Fig. 2.1). Furthermore it has been found that in developed and developing nations more than one-third of the use of total energy and CO_2 production is from the building sector (Klufallah et al. 2014). Therefore, atmospheric CO_2 emission controlling measures are crucial (Langevin et al. 2019). In order to create mitigation of CO_2 emission, planning on

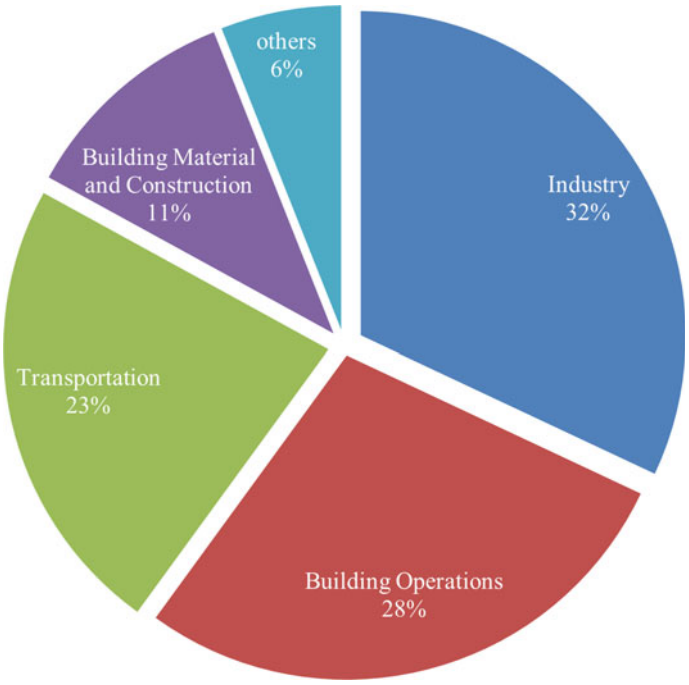

Fig. 2.1 Contribution of CO_2 emission from various sectors (Adapted after: IEA 2019)

energy conservation and implementation of effective strategies to decrease potential emission mitigation must be at first priority (Ma et al. 2019).

No doubt urbanization is going at an increased rate in these times than in the past era. The construction sector has a crucial role in the production of various pollutants particularly carbon dioxide (CO_2) into the environment. In fact building construction, onsite construction operation, and use of the built environment has been found to increase atmospheric emissions into the ambient air, huge amounts of CO_2 and other harmful gases. Different types of challenges and issues are rising from the construction sector in decreasing atmospheric emissions. Overuse of energy from non-renewable resources, weak construction design, and absence of sustainability design in the construction sector is the main reason that atmospheric emission mitigation measures are not working up to the international standards. Now therefore the atmospheric emission control schemes and different plans are important along with standard guidelines and standard frameworks. The various strategies to mitigate atmospheric emissions from the construction sector are the set policies and standards, doing impact assessment, applying low carbon emitting technology, and reducing utilization of energy. All the stakeholders in the construction sector need to play their respective roles effectively to decrease atmospheric emissions and help to fight global warming and climate change (Table 2.1).

Table 2.1 Standards associated with reducing concentration of CO_2 emissions in different buildings on Nationally Determined Contribution (NDC) set up in 2015 (The Paris Agreement Commitment and the United Nations Sustainable Development Goals)

Nation	Policies and standards
China	Energy Utilization of Buildings standard was enacted by the Ministry of Housing and Urban-Rural Development in the year 2016. The mentioned standard includes energy use indicators for different types of buildings. It has the main purpose to reduce the quantity of energy consumption of building sector energy of the nation that subsequently reduces the emission of CO_2
Australia	National Carbon Offset Standards were launched by Australian Federal Government for Building sector in the year 2017. The standards were established in association with the Green Building Council Australia. The important objective of these standards is to measure, mitigate, offset, report, and audit CO_2 exhausts from various building operations
India	The Energy Conservation Act of 2001 is a part policy and was introduced in 2016, whose main aim was at commercial buildings under the Perform, Achieve, and Trade (PAT) program. The policy has conserved almost 9 million tons of oil that is equivalent (MTOE) of energy, resulting in reducing annual CO_2 emissions almost 23 $MtCO_2$. The update in the Energy Conservation Building Code (ECBC) was done in 2017 for commercial buildings that admit improvement efforts for decarbonization. The first national model building energy code called the Energy Conservation Building Code for Residential Buildings was introduced in 2018 with much simpler implementations of thermal comfort and passive system improvement
European Union	The European Commission as part of Cleaner Energy for all the European policy packages set in 2016, targets to mitigate climate change done by GHGs, including emission of CO_2, by proposals for an efficient energy market, and strategies for renewable energy. Control of the Energy Performance of Buildings Directive (EPBD) was done in 2018 to get high-energy efficiency and decarbonisation by 2050
Sweden	The Centre for Sustainable Construction in 2016 was formed under a policy of Swedish Government to enhance the use of materials that are sustainable and energy-efficient renovations that would also reduce CO_2 emissions. A certification scheme was introduced in 2019 addressing the environmental effects of recent buildings
Japan	In 2017, The Act for the Improvement of Consumption of Energy Performance of Buildings (Building Energy efficiency Act) was included in the year 2017, which has regulatory measures for mandatory compliance with energy efficiency standards for non-residential buildings. To be achieved by 2030, the act is part of the Japanese government policy on the zero-energy-building [ZEB]/zero-energy-house [ZEH] system
Canada	Tighter energy performance standards were introduced in 2016 for energy-using product categories in buildings. In 2022, new building energy codes have been planned to be introduced as part of the Pan-Canadian Framework on Clean Growth and Climate Change to increase efficient energy in existing buildings. The Canadian Government in 2019 was working to produce a net-zero-energy-ready building code

(continued)

Table 2.1 (continued)

Nation	Policies and standards
Germany	A package of emission control measures in 2019 was formed by the German government in the building sector to meet the requirement of Agenda in the year 2030
USA	The California 2019 Building Energy Efficiency Standards was formed in 2018 as the first code in the United States of America. In 2018, the New York State Energy Research and Development Authority were formed to enhance the sustainability of buildings and efficiency of the buildings
Nigeria	The first building energy code was established in the year 2017 with a contribution between the German Development Agency (GIZ) and the Nigerian Energy Support Program having the aim of establishing minimum standards for efficient energy building construction in Nigeria
Singapore	The Code on Environmental Sustainability Measures for Buildings was launched in 2016 for existing non-residential buildings within Singapore's Building Control Regulations
Switzerland	Switzerland's new Energy Act came into force in 2018, for increased energy efficiency in buildings towards decarbonisation. It also includes the usage of a CO_2 tax on standing fuels (heating and industry). Under this Act, CO_2 tax and subsidizing of geothermal energy have been included. A central Act on Reducing the Emission of CO_2 was revised in 2019 to implement NDC in the building sector

2.2 Various Construction Activities Contributing to Atmospheric Pollution

2.2.1 Use of Onsite Vehicles and Plants

Use of plants and vehicles depends upon the onsite construction activities and also includes various types of machinery for example excavators, bulldozers, and other heavy vehicles. Various Machinery and plants that are used on construction sites are not properly governed by the authorities. Due to the higher degree and type of construction projects, equipment is running continuously and polluting the atmosphere over a longer period of time. Due to very heavy equipment machinery, and related vehicles onsite, operating more on diesel based engines, they release various types of atmospheric pollutants. This may include various types of gases like oxides of carbon (carbon monoxide and carbon dioxide), oxides of nitrogen and sulphur and other hydrocarbons.

2.2.2 Building Demolition and Land Clearing

The land for construction activities is to be cleared and made stable for construction; the process of clearing should be completed so that it makes sure that it has the minimal effects on the atmosphere. Higher levels of dust are generated with the construction of buildings to a greater extent because of disruption and demolition of existing structures.

2.2.3 Chemicals

Various types of hazardous chemicals are used at construction sites. These chemicals include various types of paints, glues, oils, thinners and plastics, which produce various types of noxious vapours and other volatile gases.

2.2.4 PM_{10}

The huge amount of construction dust produced from cement, concrete used, silica and wood from construction sites are together classified as PM_{10}. PM_{10} is particulate matter having size of less than or equal to 10 micrometres in diameter that is not visible to the naked human eye. The gaseous exhaust from diesel engines of the plant at construction sites and other machines and vehicles is also a huge contributor to PM_{10}. More precisely, this PM is also known as diesel particulate matter (DPM) as it contains sulphates and silicates that add pollutants to the atmosphere.

2.3 Issues and Challenges

The biggest confrontation in the sustainable advancement of the construction sector is the continuous increase in CO_2 emissions because of usage of un-sustainable sources of energy in processes like organization, construction, and working of buildings (Huang et al. 2018). Further CO_2 emissions also result from the wide usage of land in the process of urbanization (Klufallah et al. 2014).

Fossil fuel based energy is unsustainable, but still it contributes to a huge proportion of used energy during the activities of construction and working. Those sources of energy which are sustainable or renewable are responsible for only 6% of the overall energy utilized in this sector, whereas the utilization of fossil fuels in the construction processes is responsible for 40% of global greenhouse gas emissions. Even if various new methods are being devised for reducing the CO_2 footprint of the construction sector, especially in urban—communities with too high density, yet a lot

needs to be done (Yim et al. 2018). The use of energy that is a non-sustainable source impacts the atmosphere directly, and it is in proportion to the quantity used directly. Building construction results in the emission of CO_2 either in direct or indirect ways. CO_2 is emitted directly from the combustion of diesel, fuel oil, natural gas, and other oil—based equipment, on the other hand CO_2 is emitted indirectly from utilization of electricity. Worldwide, the indirect emissions of CO_2 contribute about 85% of the overall CO_2 generated whereas indirect emissions accounts for only 14%. As per the statement of the 2020 Climate and Energy Framework, 27% of the energy ought to be procured from sustainable sources of energy, along with that there should be 27% rise in energy efficiency or productivity (Pal et al. 2017). Moreover, numerous challenges are there in achieving solutions that are sustainable to very low achievement and high efficiency. The one possible solution can be enumeration of the processes of operation and construction in order to obtain a detailed evaluation. Construction involves the gathering of the construction material, establishment of foundation and structure, and the working and transport of equipment. The strategy includes the preservation side of a constructed building and its foundation. The prerequisite for evaluating the life cycle is the comprehensive listing of these activities during all the stages pertaining with the life cycle of a building.

2.4 The Importance of Building Green

The various processes by building green utilise those materials in construction activities which can preserve 250 metric tons of CO2 emissions on an annual basis, as per the statement of environmental group LEED. Moreover as per the latest report given by the Dodge Data and Analytics, there is a regular doubling of green building every three years, along with that it is expected that 60% of the construction a will be activities by 2018 will be green and about 70% of the survey respondents are of the view that the highest benefit of green building is the less operating cost. The research concludes that the construction firms that are increasingly being told to construct projects which are sustainable and as well as efficient in energy. The increasing trend towards the construction of building green projects has directed the Environmental Protection Agency towards the instigation of an adequate research in this field, involving the collaboration with the National Institute of Building Sciences in the formulation of Building Green Construction Code, that throws a detailed light on the approaching way of construction firms towards the green building by the incorporation of different federal rules and regulations. There are various programmes given by EPA which are given below:

Energy Star Program—Such as the Environmental Protection Agency and the Department of Energy have come together for the creation of the Energy Star program, that is responsible for promoting the usage of materials having high energy efficiency in buildings throughout the United States, according to the website of EPA.

Industrial Recycling Program—Further EPA holds specific initiatives such as the Industrial Recycling Program of the EPA, which gives awareness about how

the recycling of demolition debris and construction can be done in order to lessen impacts of the construction sector on the environment. This programme also includes the recycling of industrial materials in construction applications utilised in situ by the contract workers besides improving the product quality.

EPA's Environmentally Preferable Purchasing Program—The programme helps in improving the environment at the hands of construction companies by suggesting them to buy those products which will help in improving the quality of environment.

EPA's GreenScapes Program—Offering solutions which have cost efficiency and are eco-friendly is what this programme is meant for. The principal objective of this programme is to smother wastes along with pollution and work for the protection of natural resources throughout the construction process.

2.5 Impacts in General

The atmospheric emissions from the construction sector influencing the natural surroundings are not only contributed from the operational stage, but also incorporate those that are embodied in the whole life cycle, both from construction as well as from demolition of cities and constructed buildings. Worldwide chain supplies, including brick-making, excavation, demolition, and transportation can be hazardous for the environment, and 'build in' embodied emissions from a building. From construction, atmospheric particles of dust, such as silica dust or hardwood are also known to cause adverse health impacts including asthma, heart disease, and silicosis (Safety and Health 2015). Dust of silica that is generated during the preparation of concrete and exposure to this substance which is potentially toxic can cause threats to health across the built environment globally. This fact is evident that emissions of CO_2 result in climate change and global warming that has a tendency to pose serious impacts on human health and environment. The emissions of CO_2 in atmosphere function like blankets that absorb heat, and consequently warming up the planet (Klufallah et al. 2014). This is the layer which is responsible for preventing the earth from cooling effects, and hence elevating worldwide temperatures. Global warming has serious consequences on environmental conditions, the supply of food and water, the pattern of weather conditions, along with sea levels. The NOAA Global Climate Summary states that the temperature of ocean and land taken together from 1980 has shown an increase the average rate of which is 0.07 °C per decade. The release of CO_2 in the atmosphere results in acid rain that in turn damages trees physically (Paoletti and Manes 2003) and the built environment (Cellura et al. 2018; Bravo et al. 2006). These consequences of Atmospheric gases from the construction sector can be clearly noticed. These emissions extend enormously beyond increasing the global temperatures that are influencing ecosystems and communities all around the globe.

2.6 Consequences of Atmospheric Pollution from Construction Sector

2.6.1 Construction Workers

It has been found by research that PM_{10} can pass into lungs so deep into the persons those who take PM polluted air. Workers working at construction sites on a daily basis are at very higher risk getting complications of health. Substandard air quality because of atmospheric pollution can create the below mentioned health risks:

1. Coughing, wheeze and breathing shortness
2. Heart and other respiratory complications
3. Cancer of lungs and other organs
4. Heart and other Strokes
5. Aggravation in asthma.

In Fact in the construction sector 56% of the cancers are occurring in occupational men. For example mesothelioma, that is a cancer type that is caused due to exposure to asbestos developing on the inner lining of the two lung lobes and chest. Continuous exposure to the dusts produced and fibres generated, for example silica and asbestos, and to the fumes and gases produced by various vehicles and machines is the common reason among construction workers that lung cancer is very common. The construction workers doing their job at the construction sites are generally exposed to different carcinogenic compounds as a result of various construction activities.

2.6.2 Residents of Locality

The effects of atmospheric pollution to a greater extent are felt by people living near construction sites. People living in not in close proximity of construction sites as construction workers to the atmospheric pollutants but they may experience different effects of poor air quality. PM_{10} and known atmospheric pollutants are also dispersed by air to the near atmosphere and get settled later on. The residents near construction sites not knowingly often breathe PM and can then experience different health complications such as cough, breath shortness as a short-term health consequence.

2.6.3 Environmental Effects

Apart from adverse effects on human well being, there is an urgent need of awareness about the adverse implications of atmospheric pollutants upon the environment. Construction sites cause 14% PM 2.5 (particulate matter having 2.5 micrometers of

diameter) and about 8% of Particulate Matter 10 exhausts. Most emissions originate from the machines used in the construction sector along with generators which operate on fuel such as diesel, only 1% is represented by demolition and other activities occurring at the sites. This poses a severe threat for the survival of plants as well as animals and ultimately results in the disruption of food chain biodiversity loss.

2.7 Prevention of Atmospheric Pollution from Construction Sector

The construction process utilizes many chemicals, the majority of which if not managed or handled properly can prove detrimental to both the workers and the environment. Hence EPA laid down the recommendations for designing, installing, implementing and maintaining effective pollution prevention strategies, throughout the project course to ensure the safe and proper discharge of pollutants with less negative effects on the atmosphere. The regulations state that it is to make sure that the minimisation of production of pollutants emitted from various instruments utilized or observed at construction sites, including the vehicles at sites, the wastewater from wheel wash, and other related chemicals. Further the regulations further maintain that it needs to reduce the exposure of construction materials, end products, building wastes materials, associated products in precipitation as well as snow water. Environmental Protection Agency further stated that it is not mandatory for those construction sites where the water sources and the atmosphere around the sites of construction are not at risk due to pollutants generated

2.7.1 Pollution Prevention Strategies

The management of the amount of pollutants you generate as a firm or individually are very imperative. Strategies for pollution control are having a much positive effect on the business of construction besides curbing the adverse effects on workers, nearby residents, as well as the environment. As per the statement of the Environmental Damage (Prevention and Remediation) (England) Regulations 2015, firms are being made to pay if they cause any damage to land, water, air, biodiversity in England. The regulations have enforced an enforcement of a principle known commonly as the principle of 'polluter pays'. This policy makes businesses of construction responsible for the emissions they are creating by encouraging businesses to reduce their atmospheric impact with incentives of monetary nature. This principle is meant for holding the firms liable for the pollutants they generate by preparing them to lessen their impact on the environment via financial incentives. These are usually referred to as enforcement undertakings since these are alternatives to prosecutions, and the money is given to the projects that help wildlife. No doubt that the construction

phases produce a variety of atmospheric pollution, that it is manageable and avoidable. The atmospheric emissions produced by construction sector can be reduced by following the given suggestions:

- **Don't burn construction waste materials**. This reduces smoke and releasing of poisonous vapours for example carbon monoxide into the air.
- **Hybrid technology adaptation**. Diesel engine based excavators and diggers should be replaced hybrid prototype machines that work on electric power should be used.
- **Use low sulphur diesel**. Fuel especially diesel low in sulphur should be used to run various equipment and vehicles.
- **Improvement of existing equipment**. PM filters and catalyst converters for control of atmospheric pollutants need to be used.
- **Use water sprays or sprinklers**. These should be used to minimize different types of dust by stopping its further spreading.
- **Source local materials**. Materials from locality should be used to avoid the transportation of materials from large distance.
- Use of natural and artificial renewable and sustainable construction materials.
- **Wearing proper Personal Protection Equipment**. Such as the correct type of respiratory protective equipment (RPE) depending on the task.

2.7.2 Mitigating Atmospheric Pollution by Cause

- **Emissions from in-use buildings**: **S**ourcing of energy from renewable. Decrease emissions of operational carbon by focusing on total zero carbon building performance, which requires optimal energy efficiency for building systems and fabric.
- **Emissions from building life-cycle**: Sources from local, recycling or reuse of materials all reduce pollution produced by, transportation, demolition processes and construction.
- **Priority on production of brick**: production of higher proficient technologies, especially during brickfiring, can decrease emission of atmospheric pollutant.
- **Short Lived Climate Pollutants**: The production of Short-Lived Climate Pollutants from lighting, heating should be reduced. In addition, developments in construction quality can enhance heat well-being and eliminate demand for warming. Constructions planned according to weather, onsite usage of power and light from renewable sources is an effective result for reducing large-scale and site specific atmospheric pollutants from the construction sector.
- **Hydrofluorocarbons**: With majority of people all over the globe having health threats because of limited access to cooling in buildings for main needs of health, it is mandatory to promote accessible and sustainable cooling means.
- **Passive strategies for design**: This includes buildings that have energy efficient fabric material, ventilation and vegetation that can decline requirements for cooling in buildings and thus maintain comfortable conditions for living.

- **Dust from Construction**: Generation of dust from construction sites should be properly managed with strict organisational and national regulation, appropriate policy and practice employed on site, and other strategies for dust reduction. Off-site modular construction practices can be preferred due to more controlled dust production and lower volume.
- **Reducing Waste**: The overall process of construction can cause the generation and withdrawal of a huge amount of atmospheric pollutants. But, enhancing the work efficiency, prioritise the technologies which can effectively reduce production of waste and enhancing supplies and materials for construction helps to a great extent.
- **Exploration of Recycling Options**: Finding options for industrial recycling needs to be prioritized completely.
- **Usage of Eco-Friendly Materials/Products/Tools**: Construction industry must consume products, tools, and materials that are environmentally friendly and are designed for reduction of air pollution and consumption of energy on the construction sites.
- **Protection of Earth Resources**: Any sort of work related to construction must be aimed for protection of not only protection of environment but also include protection of plants and the animals in a given area.

Indoor Environment

- **Infiltration of Pollutants**: On an average we spend of about 90% of our overall time within the building, it is comprehensible that the major part of our exposure to outdoor pollution appears inside. In the present situation, where 91% of populace live in polluted outdoor air environments, thus it is advised to have a conscientious approach of ventilation strategy (WHO 2018).
- **Focus on fabric of buildings**: A superior building fabric can be successful way to minimize the exposure of atmospheric pollutant to infiltration and to create a more pleasant indoor air environment with expenditure of minimum energy. Fully insulated walls can efficiently work for all climates; trapping of heat can eventually keep an indoor air cool or warm as well as declining other wellbeing threats like, noise discomfort.
- Moreover, activities of people for reduction of their individual share atmospheric outdoor pollution are an appropriate way to minimizing the outdoor quality of air than that in the buildings.
- **Air Ventilation**: Enhanced levels of ventilation, with adequate screening are compulsory and are an important strategy for cleaning IAPs by exchanging clean air with fresh air, which can promote to prevent or reduce the negative health impacts. Minimum ventilation systems and plans vary according to quality of outdoor air and climate, moreover in some areas with greater concentrations of air-based particulate matter; more filtration of air is often required to keep the indoor environment healthy.
- **Mould**: Walls with mould are often present in moist, temperate climates, or cold regions as consequences of the infiltration of cold air in outdoor environment

through the cracks present in the fabric of building, often shown by a poor envelope of buildings, which after condensation forms moist layer when exposed to considerably warmer inside materials.

- In the cold regions, enhancing air tightness of building and material quality of insulation can decrease the chance of mould build up and consequent threats to health, also enhancing thermal comfort and efficient energy of the environment in the construction sector.
- In hot climates, concentration on proper ventilation system to reduce and eliminate clear condensation and stale air is important that can possibly be increased with proper air conditioning or utilization of dehumidifying equipments. If such technologies are proven to be highly efficient appliances, energised by renewable forms of energy sources, then we can potentially reduce the threat of increasing atmospheric pollution from energy generation upwards.
- **VOCs**: These are produced from a variety of regular products that includes aerosols, varnishes solvent-based cleaning products, paints, and various preservatives. The knowledge about the VOC exposure related health impacts is rising, low-VOC products or the products that can capture VOCs are getting easily available for local public, the workers of construction industry, and design professionals.
- **Toxic materials**: Varied exposure to materials that are highly toxic for example asbestos is already outlawed by local and national building codes in various regions across the globe. Countries where it has not been the case, training for architects, awareness campaigns, designers, and policy updates for the general public are beneficial strategies for reducing health threats.

The building and construction sectors must identify the liability it has to supervise and reduce the abundance of atmospheric pollutants it collaboratively creates on the environment. Of the one easiest measure to take is to be aware of the quantity of the pollutants and waste that construction activities generate and the consequences these pollutants have as far as the environment is concerned. No matter if you are an employer or construction worker in the construction sector, there are policies and regulations that decline the quantity of atmospheric pollution generated that needs to be enforced and encourage others to do the same. But ironically, the atmospheric pollution generated by construction sectors is directly affecting the environment and its potential to do its job in a sustainable manner. Anywhere in the construction sector outside the environment is polluted, passive or natural ventilation plans are not suitable. Energy-utilizing air filtration is sometimes used but this can elevate more the utilization of energy from the construction sector (unless the energy used is produced by renewable energy sources or utilizing systems which are highly efficient), that can result in a synergistic effect. Globally the demand of energy from air conditioning is estimated to triple by the year 2050, as consequences the negative effect on global air quality is bound to enhance (IEA 2018). Moreover, during construction activities within the buildings having less vulnerability to toxic chemicals or materials, the majority of the risk is from outside atmospheric pollution. When we are inside buildings, a major portion of exposure to the outdoor atmospheric pollutants happens

due to addition through cracks in the building fabric aperture or windows, apertures (Allen et al. 2017).

2.8 Stakeholder Roles in Reduction of Atmospheric Pollution

2.8.1 General Public

- Eco-clean energy should be favoured for transportation and power and to promote conservation of energy as far as possible.
- Enhance the quality of building construction and restrain unhealthy toxic compounds in furnishings; choose products with low-VOC where possible for materials example carpets or paints.
- Affective ventilation must be guaranteed for access to clean and fresh air.
- Analyse investing in an IAQ monitoring.
- Utilize a team for service management and/or landlord to deliver a better air environment for residents and occupants.

2.8.2 Business

- Cleaner energy must be chosen for transportation and power, and should enhance energy conservation.
- Good IAQ indoor air quality should be maintained with proper ventilation strategy, healthy materials and utilisation of real time monitoring of indoor air environments.
- Priority should be given to liable provision for buildings—to prioritise ethical, recycled and local, materials with potentially no or moderately low VOC concentrations that lead to emissions.
- Promote the initiatives of sustainable finance worldwide for green buildings specifically micro-financing schemes in the developing countries.

2.8.3 Government

- The authorities should prioritize investment in green energy, carbon depletion and promote decentralised renewable networks of energy in rural areas.
- The government should support efficient forms of energy by enhancing standards related to building and should be encouraging the retrofit programmes.
- More secure and sustainable construction methods should be incentivised.

- There should be implementation of national guidelines for IAQ and building ventilation.
- Utilisation of recognized toxic materials be discouraged, and administration should legislate a minimum standard for contaminants with potential high risk.
- The government authorities should supervise the outdoor air environment and to disclose data publicly, and encourage IAQ monitoring in high occupant areas such as hospitals, offices and schools.

2.9 Conclusion

Everywhere in the world there is some sort of construction activity going on that is very helpful in developing the nations and increasing the standards of living. The construction industry plays a crucial role in the emissions of various pollutants in the atmosphere. The humongous production and release of pollutants from the construction sector have been found to have severe consequences and impacts contributing to global warming and climate change. The various deleterious impacts of the non-sustainable construction activities have not only put a stress on the environment but have also impacted humanity. Energy generated from fossil fuels is no doubt non-sustainable, but it contributes for a higher percentage of the energy utilized in the construction and operation processes. The various basic strategies to reduce atmospheric emissions from the building industry are the policies and enforcing standards, conducting impact assessment, adoption of low carbon technology, and minimizing use of energy. If we humans continue with the current policies and approach in the reduction of atmospheric emission from the construction sector, it will be very late to rectify and undo the mistakes that have been done in the past. We will fail to achieve the goals of global sustainable development and the near future of sustainable communities and sustainable cities will remain uncertain. The construction sector must be provided with enough attention and care so that it can reduce and curtail the atmospheric emissions effectively. A very comprehensive analysis is needed to study the nature of atmospheric emission, rate of emissions, quantity, quality and controlling measures in the construction sector, and local and world organizations must frame a sustainable inclusive framework to handle the issue of harmful emissions from the construction sector. For a sustainable future of the world, it is very necessary to impose necessary actions and measures to curtail emissions from the construction sector and that will lead to contribute in the fight of combating climate change.

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