

Review

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Review

Different Methods and Technologies of Controlling Air Pollution-An Overview

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Abstract: Environment pollution is the major problem for all the sectors. In environment pollution there are different types of pollution is included such as air pollution, water pollution, soil pollution etc. In these types of pollution most of it is air pollution. There are many reasons for pollution of air. Human advance in science but one of the major draw backs of science is the pollution of air rapidly. Air pollution is injurious to health. Every year a large number of people died for the effects of air pollution. It can be improved in many ways among these ways technology upgradation plays a major role here. There are various method that prevent air pollution. Many researchers tried and is trying to prevent the air pollution in many ways. In this review paper I summarise the existing research on different ways for preventing air pollution in addition I will discuss the gaps and future aspect on this topic.

Keywords: air pollution; air pollution control; environment pollution; CO; PM; VOCs; Electrification

1. Introduction

Nowadays air pollution control is most talked topic. Industrialization is the main cause of air pollution but there are some more causes which can't be ignored such as smoke that emitted different kinds of vehicle, urbanization without planning, Smoke emitted from brick field, cutting down trees, from ship etc. There are different kinds of element that polluted air. SO_x

, NO_x, CO₂, CO, O₃, PM_{2.5}, PM₁₀ are the main element that pollute the air. Particulate Matter which is less than 2.5µm can move with help of air and transfer dangerous compounds to the lungs of human [8]. It creates big health issue.[7]. One of the main challenge of the Anthropocene epoch is the air pollution crisis, which brings both health and economic growth [7]. The Global Burden of disease (GBD) study shows that in 2015 there was 9 million deaths were associated with various forms of pollution of which 6.5 million deaths were caused by air pollution (GBD, 2015). Moreover the gross domestic product of low income and middle income countris are reduced by air pollution by 2% yearly [7]. If air pollutants are not controlled carefully, air pollution may continue to be a risk factor for human health [7]. The one of the effective method to control air pollution is cutting down emissions [16]. Air pollution control effectiveness is mainly depends on the country's economic status, governmental willingness and political situation [16]. The local problems addressing is easy if there is focus and flexible policy [16]. Developed country like Chaina, USA have industrialized so much that the air quality of these country has worsen. In the southeast Asia Chaina has urbanized and developed in technology. In recent years they are focusing on air pollution control. Different research took place for controlling air pollution that shows upgrading in technology is the most prominent way to control air pollution. There are some alternative ways that will also help to control air pollution such as photocatalysis, strictly maintaining environmental law, good planning of city, using alternative fuel in vehicles, radical induced oxidation, using renewable energy, stainless steel catalyst, green infrastructure, energy intensity, biofiltration etc. Biofiltration, is a air pollution control technology in which off-gases containing biodegradable volatile organic compounds (VOC) or inorganic air toxics are vented through a biologically active material [19]. Coal remain a significant power supply source worldwide as expected. Improving in emission control is key to improving air

quality which can be done by technology [1]. Photocatalysis has been proved as a good method of removing environmental pollutants from atmosphere [2]. Photocatalysis means the photogeneration of strong oxidation and reducing agents at the surface of the catalyst that destroy pollutants especially organic pollutants [2]. The air pollutant in indoor or semi enclosed area should treat with visible light driven photo catalytic, or photolysis is [6]. Nitrate component of PM_{2.5} has not responded great to decreasing emissions of nitrogen oxides and has actually increased during winter haze pollution [10]. The solo cause of this increase in nitrate is weak deposition [10]. Air pollution hotspot are not always involved to heavy traffic, proper urban design can reduce air pollution [11]. The GIR technique inspired by google ranking can help to rank the city according to their situation [12]. Sensor module can also reduce air pollution [13]. It can be placed in the toll booth and traffic light signal area [13]. Plant leaves can grab PM and ambient concentrations is reduced [14]. SO₂, NO_x, PM and CO₂ emissions for non-power sector can reduced by energy intensity improvement [15]. Shipping companies are also responsible for air pollution. Oil produces black smoke and it contains significant amount of NO_x, CO, CO₂ etc [17]. In the present time international shipping and port industries has work on new technologies such as fuel quality improvement and engine technology [17].

2. Literature Review

There are numerous methods and technologies to control the air pollution. Most effective ways are given below:

Improving emission control technology:

Table 1. Summary of techniques to control air pollution [1].

Techniques	SO ₂ (%)	NO ₂ (%)	Mercury (%)	PM (%)	Cost (\$)	Applicability
Advanced dry scrubber	90-95	-	0-90	-	50-150/Kw	Pilot to commercial scale; depending on type of coal
Activated carbon injection with ESAP	-	-	50-90	99	ACI:3-8/Kw	Pilot scale, retrofit and new plants with Fabric filter (FF) and ESP
Combined Hg and SO ₂ sorbents	40-85	-	Upto 90	-	30-60/Kw	Pilot scale, integrated with ESP or FF unit
WFGD with mercury oxidation process	95	-	>80	90 for >10µm (up to 39.6% for PM _{2.5})	160-275/Kw	Pilot scale testing
Wet scrubbers with WESP	99	-	80	90-99	WESP:10-20/Kw	Commercial level; integrated with already installed wet scrubbers
Activated coke	90-98	15-80	90-99	80-85	150-200Kw	New plants and retrofits
SCR with WFGD	95	90-95	40-90	90 for >10µm (up to 39.6% for PM _{2.5})	SCR:50-40/Kw Wet.FGD:160-275/KW (for 400 MW)	Commercial level
Electrocatalytic oxidation	98	90	90	86	200/Kw for 500 MW	Demonstration level; new plants and retrofits

Photocatalyst immobilization methods: By photocatalysis method we can remove several pollutant from the environment. There are many techniques from that sol-gel technique was researched well compare to other and it had the highest removal rate normally for NO_x at 16 mg m⁻² min [2]. On the other hand thermal spraying (TS) on average was found to have highest Volatile Organic Compounds (VOCs) removal at 107 mg m² min [2]. VOCs used a batch style reactor in most of the studies evaluated the removal which could not real condition [2].

Radical- Induced Oxidation:

For treating the air pollutants that emitted from flue gas needs to use the extra oxidants as the radical precursors. The following table will shows the efficiency of removal of multi pollutants with different kinds of radical

Table 2. Summary of removal of multi air pollutants with different kinds of radical [6].

Name of radical	Efficiency of SO ₂ removal (%)	Efficiency of NO _x removal (%)	Efficiency of Hg ⁰ removal (%)
Hydroxyl radical	99-100	75-100	75-98
Sulphate radical	9-100	72-100	85-99
Chlorine radical	99-100	77-98	90-95
Ozone	97-100	91-97	82-91

Renewable energy Increasing:

China and India for example [8] China's air pollution control cost could cut cost by 17-35% with a 1% increase in the renewable energy and it is more than two third of cost for India. CO₂ emissions can be reduced and it will help to control NO_x and PM in the provincial level of China. But it can not control SO₂ effectively [8].

Stainless steel catalyst:

Among developed air pollution technology, catalysis (including catalytic oxidation and catalytic reduction) is used very widely, energy-saving, and free of secondary pollution [9]. It has a great possibility for emission reduction, which makes them an inevitable choice for in-depth air environmental control worldwide [9]. Stainless steel catalyst has almost same properties as the diesel engine that's why it can be installed near the engine and regulate the emission [9]. The Co-Ba-K/ZrO₂/AISI 314 foam catalyst can be prepared and can be achieved simultaneous removal of soot and NO_x [9]. Catalytic combustion is a good energy-saving and effective method [9]. It can catalyze the deep decomposition of VOCs into CO₂ and H₂O at lower temperatures (200 – 500 °C) by the selection of right catalyst. Stainless steel is not expensive and available, and its elemental composition makes it an effective catalyst support for VOC oxidation. For denitrification in tail gas, selective catalytic reduction (SCR) of ammonia is the perfect technology. N₂O is a good ozone-depleting agent and greenhouse gas. Its global warming effectiveness is 300 times higher than that of CO₂. Monolithic support of stainless steel has been widely used in N₂O decomposition [9].

Biofiltration:

Biofiltration is a process by which CO₂ presented in the air can be reduced. It is passing a stream of polluted air through a bed filled with solid media before it is washed away or increased the moisture. Biofilter has microorganisms such as methanotrophs, ammonia oxidizers, oligotrophic bacteria, fungi, and algae which break down the pollutants.

NH₃ Emission Reduction:

A study GEOS-Chem model shows that only 8.6% PM is reduced by reducing 30% of VOCs and NO_x in winter. NH₃ is the most effective way for PM_{2.5} nitrate control specially on winter haze days. It is beneficial to reduce NH₃ in any amount. By reducing NH₃ emissions by 50% the reduction of Nitrate PM_{2.5} will be 25% and will be 31% in haze days. Total reduction of NH₃ emissions by 50% reduces total PM_{2.5} by 13% in the winter, 18% in winter haze days and 14% annually [10]. The one of the main sources of NH₃ is agriculture and it could be controlled by application of limited fertilizer and better management manure.

Traffic Condition and Urban Planning:

Two types of reduction strategies are introduced to mitigate the city air pollution

1. Traffic system improvement
2. Urban planning efficiency improvement

Traffic system can be improved by creating low emission zone and there should be strict law for breaking traffic law that can reduce air pollution moderately [11]. As study shows heavy-diesel vehicle emit 40%-60% of NO_x and 70% to 90% CO₂ emitted by black smoke of it [11]. One-way traffic is more effective [11]. By reducing the number of heavy diesel vehicle and improvement of pavement quality of road can help to limit the air pollution [11]. Electric Vehicle and improvement of engine can mitigate the traffic system problem [11]. Among the two ways EV is considered the most effective way [11]. The emissions of VOCs is 98% and NO_x is 34% lower than the traditional vehicle [11]. Strict regulation are also very important to reduce transportation related pollution [11]. The other major

step is urban planning. In cities air ventilated to open space. Height of building are important in this case of reducing air pollution [11]. Wind speed, sun light, temperature, humidity these weather condition should take into consideration. Chemical reaction is also important to reduce air pollution such as planting trees on the roadside [11].

XG Boost and Grid Ranking:

Many research has been conducted but the researches did not cover full area's air quality accurately. The GIR techniques is similar to google page rank algorithm that is mainly work for ranking the page according their influence [12]. The mechanism of the variable importance is combined in XG Boost [12]. XG Boost is a machine learning algorithm which is non linear [12]. The method can identify the areas that the most influence on other and to control the air pollution these areas should be targeted [12]. It is shown from a study that XG Boost can make a model of different areas [12]. The government should give priority to control air pollution according to importance map such as southern Oregon is considered in importance map in north USA [12].

Cloud computing-based air pollution monitoring system:

The system works that way the air pollution data will stored in a common data base [13]. The sensor module is placed in toll booth collection centre and traffic light signal area [13]. When the vehicle crosses any traffic light area or toll booth area by using that project module it will check the pollution level of the vehicle and it updates the data in the cloud data base [13]. If the vehicle shows more emission of gas it is recorded to the local police station and to the vehicle owner about the over limit emission of gasses in vehicle [13]. If the vehicle shows the same level of emission of gases, then local police station will be taking action [13]. Date expiry of insurance and smoke test status can be checked by the module [13].

Green Infrastructure for air quality:

The canyons of street are usually highly polluted due to high traffic [14]. Green Infrastructure (GI) is one of the major air pollution mitigation system where there is a lack of place for plantation green walls, green screen, green roof can be viable green infrastructure option [14]. The influence of green infrastructure options on air quality depends on geometry of the street canyon [14]. Deposition of vegetation can be a short-term solution for air pollution control [14]. Planting vegetation on roadside can reduce PM by 60% and reduce 40% of NO₂ [14]. If there is place for tree plantation it is a great way to reduce air pollution. Many people plant small trees in a pot and put that on the roof of a house and there are many trees that have the nature to grow on a roof top.

Energy Intensity Improvement and Electrification:

Energy intensity improvement can reduce SO₂ emissions by 26%-44%, NO_x emissions by 19%-44%, PM by 25-46%, CO₂ emissions by 18%-50%. SO₂ emissions can be reduced with the help of electrification by 19%-25%, NO_x emission by 4%-28%, PM emission by 20%-29%, CO₂ emissions by 11%-12% [15]. The largest range of co-benefits for sub sectors is the non-ferrous sector: its reduction rates for SO₂ emissions is 20.9% to 55.8%, for NO_x emissions is 17.5% to 44.6%, for PM emissions it is 24.5% to 47.8% and for CO₂ emissions 24.0% to 58.3% [15]. The reduction rates of paper sector is also very high for NO_x it is 7.9% to 38.1% and for CO₂ it is 9.6% to 41.3%, respectively, but its reduction rates for SO₂ and PM emissions are not high [15]. The largest average direct co-benefits is the non ferrous sector, and the smallest average direct co-benefits is the paper of the non-power sectors [15]. The average reduction rates of SO₂ emissions are 43.7% , NO_x emissions are , 44.2%, PM emissions are 46.4% and CO₂ emissions are 49.6% for the non-ferrous sector respectively [15]. The average reduction rates of SO₂ emissions are 25.5%, NO_x emissions are 24.1% , PM emissions are 32.5% and CO₂ emissions are 18.5%, respectively, which are still large. Since the energy intensities of CPPs are more concentrated, the direct co-benefits of CPPs is not very good for non-power sector [15]. The reduction rates for CPPs of SO₂ is 6.1%, NO_x is 3.6% , PM is 6.0% and CO₂ emission is only 2.5%, respectively [15]. The emissions reduction rates of NO_x emissions are most diversified [15]. In NO_x emissions the petroleum sector and the non-metallic sector have the largest reduction rate [15]. When 30% of the fossil fuel used in these two sectors is replaced by electricity, their reduction rates of NO_x emissions are 19.3% and 27.6%, respectively [15]. The reduction rates of NO_x emissions

other four sectors have less than 12% [15]. In different sectors the rate of CO₂ emission is almost similar, electrification is used in the place of fossil fuel from 12-30%[15].

4. Discussion

In the paper I collect the previous knowledge about air pollution prevention method and technology. Technology upgradation is the key here. But there are some limitations for both methods and technologies such as photocatalysis immobilizing method can reduce organic pollutant well, renewable energy innovation cannot reduce so₂ significantly. Biofiltration is one of the best way to reduce co₂ and it is also cost effective. For technology XG Boost and Grid importance ranking is a theoretical concept, cloud computing-based module need high technology and its costly. Plantation of tree and vegetation deposition is a way of reducing air pollution. Green infrastructure is a short term solution for reducing air pollution. There should be large scale and long-term plan. Government policy can be helpful but it is doubtful that people will strict to the law. Public awareness is one of the most effective way to implement any environmental law accurately. Electric vehicle can be a effective way to prevent the air pollution but slightly higher SO₂ and PM is found. For prevention from existing pollutant people should take healthy diet. That's the good way to prevent any other disease.

5. Conclusions

Air pollution is now a most talked topic. Air pollution is dangerous for our health and it is the major cause of climate change. There are many methods and technology for controlling air pollution but existing pollution cannot be control. So in this paper I summarize the methods and various technologies for controlling air pollution. The methods discussed earlier in this paper should be applied different sector in the country so that we can achieve our goal to reduce air pollution and that's the only way to save the world from climate change.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, X.X. and Y.Y.; methodology, X.X.; software, X.X.; validation, X.X., Y.Y. and Z.Z.; formal analysis, X.X.; investigation, X.X.; resources, X.X.; data curation, X.X.; writing—original draft preparation, X.X.; writing—review and editing, X.X.; visualization, X.X.; supervision, X.X.; project administration, X.X.; funding acquisition, Y.Y. All authors have read and agreed to the published version of the manuscript.", please turn to the [CRediT taxonomy](#) for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

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