

Detection And Control Measures Of Air Pollution

Shveta Arya

Abstract: Air pollution is the contamination of atmosphere of particulates, biological and chemical materials that result in discomfort, death or diseases to humans as well as other living organisms, it also damages food crops, built environment and natural environment. With time there is increase in air pollution either due to primary sources or secondary sources. This is a review paper that covers various primary and secondary pollutants produced by human activities. There can be two causes of air pollution either by human being or natural hazards both are covered in it so that one become able to know the difference. The major problem in air pollution is its detection so a brief review on work done by various researchers in detection of air pollution has been presented in this study. After detection of air pollution next step is methods and approaches that can be used to control it so a comparative account has been attempted which help other researchers to choose approach according to their requirements. There are a number of air pollution detection and controlling methods used by various researchers and review on it help in gathering the knowledge about the best approach for the area and type of pollutants on which they are working.

Index Terms: Air pollution, Causes, Pollutant types, Control methods, Detection methods

1. INTRODUCTION

In order to sustain healthy lives of humankind and those of the supporting ecosystems, there is need of clean air. Due to widespread industrialized growth there is release of various particulate matter and gaseous emissions. Industries pump various kinds of gases and waste into the atmosphere that lead to formation of new pollutants by various chemical reactions taking place in the atmosphere [1]. The air pumped by industries is primary pollutants and secondary pollutants are chemical reactions in the atmosphere. For many years a threat to human health has become a prominent global threat that creates a need to build up the concern of ambient air pollution (AAP). According to the IPCC fifth assessment report human health gets damaged by nearly all the non-CO₂ climate altering pollutants. Human health can be affected directly or indirectly by contributing secondary pollutants in the atmosphere. Air pollution is the introduction in atmosphere of unwanted particles that consists of particulates, biological and chemical materials that results in discomfort, death or diseases to humans as well as other living organisms, it also damage food crops, built environment and natural environment. Air pollutant is a substance in the air that can be adverse to humans and the environment. These pollutants can be in different forms like liquid droplets, gases and solid particles that can be natural or man-made [2]. Primary and secondary are two classifications of pollutants. The volcanic eruptions, factories releasing Sulphur and motor vehicles exhausting Carbon monoxide gas are primary pollutants that are directly produced from a process, on the other hand secondary pollutants are not emitted directly. The ground level ozone is an important example of a secondary pollutant and it is considered as one of the secondary pollutants that make photochemical smog. Some pollutants may be both primary and secondary as they are emitted directly and formed from other primary pollutants.

There are various types of pollutants available in atmosphere that directly or indirectly affects our lives. This paper focuses on various primary and secondary pollutants that create air pollution. Due to increase in concentration of pollution in the air there is need to propose an air pollution control and detection methods or approaches. An attempt has been made to compare various air pollution control and detection methods proposed or used by various researchers.

2.MAJOR POLLUTANTS

This section of the paper includes various primary and secondary pollutants produced by human activities.

2.1 Major human activity produced primary pollutants are:

- Sulphur Oxides (SO_x): It is produced in various industrial processes and volcanos. The sulphur dioxide is generated by combustion of sulphur compounds present in petroleum and coal. The oxides of sulphur and nitrogen react in the air to form sulphuric acid and nitric acid that forms acid rain.
- Nitrogen Oxides (NO_x): It is excluded from high temperature combustion and by electric discharges naturally produced from thunderstorms. NO₂ is a chemical compound that is seen above cities plume downwind and brown haze dome [3]. Sharpness and biting odour are some of the characteristics of this reddish brown toxic gas that makes it one of the most prominent air pollutants.
- Carbon Monoxide (CO): CO is odourless, colourless and non-irritating but it is very poisonous gas produced by coal, wood or natural gas by incomplete combustion. Major source of carbon monoxide is vehicular exhaust.
- Volatile organic compounds (VOCs): It is one of the important outdoor air pollutants that are often divided into separate categories of nonmethane (NMVOCs) and methane (CH₄) volatile organic compounds. The global warming get enhanced by extremely efficient greenhouse gas Methane and other hydrocarbon VOCs also contribute to global warming by prolonging the life of methane in the atmosphere. The industrially used 1,3-butadiene is also a dangerous compound and aromatic compounds like toluene, xylene and

• Shveta Arya, Assistant Professor, K.L.Mehta Dayanand College for Women, Faridabad, India, dr.shvetaarya@gmail.com

benzene present in NMVOCs are suspected carcinogens.

- **Particulates:** It is also known as particulate matter (PM), fine particles, and atmospheric particulate matter, are tiny particles of liquid or solid suspended in a gas. The aerosol is referred to gas and particles together and particulates sources can be natural (dust storms, sea spray, grassland and forest fires, volcanoes) or manmade (power plants, various industrial processes and burning of fossil fuels in vehicles). The anthropogenic activities account for 10% of the total amount of aerosols in our atmosphere over the globe. The diseases like lung cancer, lung malfunction and heart diseases like health hazards are caused by an increase in levels of fine particles in the air.
- **Chlorofluorocarbons (CFCs):** It is produced from cleaning solvents, aerosol propellants and refrigerants that is harmful for the ozone layer.
- **Ammonia (NH₃):** It is a compound emitted from agricultural processes. Ammonia is normally encountered as a gas with a characteristic pungent odour that is either directly or indirectly a building block for the synthesis of many nutrients, fertilizers and pharmaceuticals. Although it is widely used, it is classified as extremely hazardous substance by United States.
- **Persistent free radicals:** This can cause cardiopulmonary diseases by connecting to airborne fine particles.
- **Odours:** It is generated from sewage, industrial processes and garbage.
- **Radioactive pollutants:** It is produced by nuclear events, nuclear explosions, war explosives and radioactive decay of radon like natural processes.
- **Toxic metals:** Toxic metals are also one of the primary pollutants that consist of mercury, lead and their compounds.

2.2 Secondary Pollutants are:

- **Particulates:** It is created from primary pollutants gaseous and photochemical smog compounds [4]. The word smog is a combination of fog and smoke that is made from large amounts of coal burning in an area caused by a mixture of sulphur dioxide and smoke. Now a days smog mainly comes from industrial and vehicular emissions not from coal. It forms secondary pollutants in the atmosphere when acted on by ultraviolet light coming from the sun.
- **Ground level ozone (O₃):** Both NO_x and VOCs form O₃. These two considered as a key constituent of the troposphere and various chemical processes derived by number of photochemical reactions. It occurs in day and night of atmosphere and when its concentration becomes very much high then it act as pollutant. Mainly it occurs by combustion of fossil fuels.

3. CAUSES AND FACTORS RESPONSIBLE FOR AIR POLLUTION

As given above that air pollution can occur from both human and natural actions. Volcanic eruption, pollen dispersal, forest fires, wind erosion, natural radioactivity and evaporation of

organic compounds are various natural events that cause air pollution [5]. Its source can be activities or factors and various locations responsible for releasing pollutants into the atmosphere.

3.1 Natural Sources of Air pollution:

- **Dust from natural sources:** These are usually large areas of land with very less or no vegetation
- **Methane:** This is emitted during digestion of food by animals like cattle.
- **Radon gas:** It is extracted from radioactive decay within the crust of earth. Radon is a naturally occurring odourless and colourless radioactive noble gas formed from radium decay. It results in health hazard and can be accumulated in buildings like basement or other confined areas. After cigarette smoking, radon gas is considered as the second most frequent cause of lung cancer.
- **Carbon monoxide:** It is generated from wildfires.
- **VOCs:** An environmentally significant amount of VOCs is emitted in some regions of vegetation mainly on warmer days [6]. Then anthropogenic pollutants like NO_x, SO₂ and other carbon compounds react with each other and VOCs and produce a seasonal haze of secondary pollutants.
- **Other natural sources** can be volcanic activity that produces particulates of Chlorine, sulphur and ash.

3.2 Man-made sources:

Mainly man-made sources of air pollutants are related to burning of various kinds of fuel. Some of the man-made sources are:

- **Stationary Sources:** This includes manufacturing factories, power plants and waste incinerators along with furnaces and other types of fuel burning heating devices that generate smoke stacks. The major source of air pollutants in poor and developing countries are wood, dung and crop waste including traditional biomass.
- **Mobile Sources:** It includes aircraft, marine vessels, motor vehicles and effect of sound.
- **In forestry and agriculture management** of dust, chemicals and controlled burning practices also cause air pollution. In farming, greenhouse gas abatement, forest management and prairie restoration uses a prescribed or controlled burning technique. In both grassland and forest ecology, fire is a natural part and for foresters, a controlled fire can act as a tool [7].
- **Waste deposition:** Methane is generated from waste deposited in landfills that is highly flammable and forms explosive mixtures with air.
- **Military:** Air pollution is also generated by nuclear weapons, germ warfare, toxic gases and rocketry used by military.
- **Other man-made sources** of air pollution are fumes from hair spray, aerosol sprays, paint and other solvents.

4. DETECTION OF AIR POLLUTION

The carcinogenic and ubiquitous air pollutant was described by S. Mariano, et.al, (2010), for development of new chemical sensors in order to detect formaldehyde. In order to trap targeted pollutant a sponge like nanoporous matrices were

used for making sensors and formaldehyde selective detection was done by doping it with Fluoral-P. For homes a progressive colorimetric pollution warning kit was provided that was able to display a progressive change in colour by visible eyes. The low cost digital device is available for precise and quantitative measurement of air quality in public area. The main problem with available various types of sensors in market was efficient use of sensor network so that it can sustain for long time and efficiently process collected data. So, number of sensors installing methods can be used in polluted area. But the method proposed by Amnesh Goel, et.al (2012), was able to focus on longer sustain time period of sensor network by effectively processing the collected information and in information routing between sensor nodes there were less overhead [8]. Every vehicle has emissions but when it goes beyond the standardized values then it becomes a problem. We can't avoid it completely but it be controlled. So for detecting this level of pollutants popular semiconductor sensors were used by Siva Shankar Chandrasekaran, et.al, (2013), at emission outlets of vehicles [9]. In vehicle a buzzer will indicate a pollution level beyond the threshold level and stop vehicle after a certain period of time not immediately so that driver can park their vehicle in a safe place. Then during that time a nearest service station was located by GPS and there will be cut-off of fuel supplied to engine and vehicle has to be towed to nearest service station. There was microcontroller that monitored and controlled the entire process execution and synchronization. When, this paper was augmented as real time project than it gives benefit to society and help in reduction of air pollution. For automatic recognition of air pollution and fog from a vehicle Philip Sallis, et.al, (2014), have described the method [10]. They have demonstrated that Light Detection and Recognition (LIDAR) technology along with front camera can be used for improving the weather condition recognition for the purpose of autonomous driving. The evaluation of it shows that combination of LIDAR laser scanner and front camera gives good results when sensor instrument was set for air pollution and fog recognition. This will give accurate data of weather alerting systems and driving assistance. A moderate ranging imaging spectroradiometer (MODIS) image data were used by Bin Zou, et.al, (2014), for generating urban aerosol optical depth (AOD) with 500 m resolution for Greater Los Angeles area [11]. Then for mapping urban PM_{2.5} concentration a land use based regression (LUR) model or Model B was built using AOD. In this they have combined leaf area index and population density and then compared the results of ordinary kriging (OK) interpolation and LUR model or Model A without AOD to evaluate accuracy of modelling method. From results it has been seen that over the city there is variation in AOD values and it becomes high in downtown area. Another thing was that by incorporating AOD data there is increase from 0.28 to 0.35 in LUR model correlation coefficient and as compared to Ordinary Kriging interpolation method air pollution distribution with a smaller relative error was revealed by proposed LUR model (B). The PM_{2.5} pollution AOD aided LUR model revealed urban areas with high spatial resolution. In city worldwide it provides support for migrating the growing concerned air pollution. Then in Banting Selangor a concentration of air pollutants detection using Precipitable Water Vapour (PWV) index variability clarification was the motive of Wayan Suparta, et.al, (2015) [12]. To achieve their motive they have developed a fuzzy clustering means based

PWV. Very low, low, moderate, high and very high are five categories of PWV index. On daily averaged northeast monsoon, southwest monsoon, two transition period and April to December, for these five periods a correlation analysis was performed. The test was conducted on it that shows during northeast monsoon there is small impact of air pollutants towards PWV index that was not correlated during southwest monsoon. On PWV index the impacts of O₃ and SO₂ concentrations was small and it also not get affected by other concentrations for yearly periods. There is also reduction in PWV index and increase in concentration of air pollution during haze episode. Overall the air pollutants concentration gives small impact to PWV index variability. Around the cities the measurement of gas level of air contamination was the main motive of Suganya E, et.al, (2016), research work along with reduction in manpower and increasing overall flexibility of both receiver and sender [13]. Monitoring of the air contamination by moving vehicles of CO, NO₂ levels, humidity, temperature by using CO sensor, NO₂ sensor, Humidity sensor and Temperature sensor was the main motive of proposed system. They have used Mobile Ad Hoc Network routing algorithm that has 28 mobile nodes which covers area of 300 m around the city. Then sensing data by sensors it was sent to smart phones of appropriate drivers that help in effective monitoring. The transmission speed, coverage area size, data type, No. of vehicles and system coverage were main parameters focused and closely monitored by proposed system. The anomalies in detection for measuring air quality data is a crucial step for improving the monitoring of air quality networks. So, MajdiMansouri, et.al, (2017), have proposed a moving window generalized likelihood ratio test (MW-GLRT) based multiscale principal component analysis (MSPCA) enhanced fault detection technique for air quality monitoring network [14]. By increase in false alarms rate there is reduction in quality of fault detection techniques due to presence of model uncertainties and presence of measurement noise in the data. In their proposed method they have used wavelet-based multiscale representation of data to enhance the fault detection of air quality monitoring network [15]. This is a powerful feature extraction tool that was able to remove noises from the data and principal component analysis fault detection abilities were enhanced using multiscale data representation. As compared to conventional MSPCA based GLRT method better results were achieved using proposed method on other hand as compared to conventional MSPCA and PCA methods better results achieved using both. SarunDuangsuwan, et.al, (2018), have presented air pollution detection sensors and monitoring development for Thailand 4.0 smart city. For development purpose a PM₁₀ (Particulate matter), SO₂ (Sulphur dioxide), O₃ (Ozone), NO₂ (Nitrogen dioxide) and CO₂ (Carbon dioxide), these five standard sensors were designed [16]. Then air quality index graph were checked using web monitor and Arduino MEGA 2560 was used for data processing. For Narrowband Internet of Things (NB-IoT) module network connection a Rasberri Pi 3 was used. The measurement location and experimental setup was done at Sai Mai Districk, Bangkok that shows the good air quality through AQI level of measured location.

Table 1: Comparative study of Various Air pollution detection methods

Author name	Approach used	Motive of Work	Type of air pollution	Area	Outcome
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S. Mariano, et.al, (2010),	A sponge like nanoporous matrices were used for making sensors	To trap targeted pollutant	Carcinogenic and ubiquitous air pollutant	Public area	For homes a progressive colorimetric pollution warning kit was provided that was able to display a progressive change in colour by visible eyes.	(PWV) index variability clarification				
Siva Shankar Chandrasekaran, et.al, (2013)	They have used Popular semiconductor sensors	To reduce pollution by vehicular exhausts	Vehicle Pollution		If this method is augmented as real time project then it gives benefit to society and help in reduction of vehicular air pollution	NO ₂ sensor, temperature sensor, Humidity sensor and CO sensor	Measurement of gas level of air contamination	monitoring of Air contamination of NO ₂ , CO levels, humidity, temperature by moving vehicles		The transmission speed, coverage area size, data type, No. of vehicles and system coverage were main parameters focused and closely monitored by proposed system.
Philip Sallis, et.al, (2014),	Light Detection and Recognition (LIDAR) technology	improving the weather condition recognition	automatic recognition of air pollution and fog		The evaluation of it shows that combination of LIDAR laser scanner and front camera gives good results when sensor instrument was set for air pollution and fog recognition. This will give accurate data of weather alerting systems and driving assistance.	Moving window generalized likelihood ratio test (MW-GLRT) based multiscale principal component analysis (MSPCA) enhanced fault detection technique	Air quality monitoring network			As compared to conventional MSPCA based, GLRT method better results were achieved using proposed method on other hand as compared to conventional MSPCA and PCA methods better results achieved using both.
Bin Zou, et.al, (2014),	Regression (LUR) model or Model B was built using AOD	For mapping urban PM2.5 concentration	PM2.5 pollution	Greater Los Angeles area	In urban areas the AOD aided LUR model was able to reveal that spatial pattern of PM2.5 pollution with high spatial resolution and provide a support for mitigating the growing concerned air pollution in city worldwide	PM ₁₀ (Particulate matter), SO ₂ (Sulphur dioxide), O ₃ (Ozone), NO ₂ (Nitrogen dioxide) and CO ₂ (Carbon dioxide), five standard sensors	Measuring air quality		Thailand and 4.0 smart city	The measurement location and experimental setup was done at Sai Mai District, Bangkok that shows the good air quality through AQI level of measured location.
Wayan Suparta, et.al, (2015).	Fuzzy clustering means based PWV	A concentration of air pollutants detection using precipitable water vapour	O ₃ , SO ₂	Banting Selangor	On PWV index the impacts of O ₃ and SO ₂ concentrations was small and it also not get affected by other concentrations for yearly periods.					

5. CONTROL MEASURES OF AIR POLLUTION

Solution efforts on pollution are a big problem. Due to it for controlling air pollution better way is prevention of it. These prevention methods can come by individual actions or from laws made by government. This section of paper covers various control strategies and approaches used by various researchers. The human comfort and productivity get increased by good indoor air quality (IAQ). XiaosongGu, et.al., (2008), have presented an IAQ control method for self-adaptive PID control theory based air-conditioned room [17]. The PID controller has three parameters that were controlled by fuzzy algorithm then it was applied to nonlinear controlled

object-indoor CO₂ level. This important IAQ index can be controlled by fresh air volume. By considering addition of continuous disturbances to indoor CO₂ emission sources and changing controlled object characteristics of actual conditions a simulation experiment was conducted by them. By results evaluation it has been predicted that adaptive PID controller is more robust, has better control performance and gives faster dynamic response time as compared to single PID or fuzzy controller. Then for air pollution control and monitoring a P-Sense or pollution sense system was presented by Diego Mendez, et.al, (2011) [18]. The motive behind this system was to allow international organizations, government officials and communities to have individual access to the pollution data for addressing their particular needs and problems. With different granularities with space and time a large amount of pollution data was provided by P-sense. The AQI of state, country or city was monitored and controlled by government officials and the respiratory problems of patients can be correlated by doctors according to the AQI exposed by them in their daily activities. This data can be used by realtors, country officials and community developers for determining the best place to build a new community or school. The pollution migration patterns, source model, biggest pollution ground model and air pollution control trajectory model were built by Zhaodong LI, et.al, (2011) [19]. For building all these models they have analysed the air pollution diffusion, concentration distribution scope of pollution and spread diffusion form of pollution. Various factors like efficiency, audit or risk opinions, indicators, scope economic and effectiveness, pollution migration trajectory model was the most objective, accurate and comprehensive audit model. A regional air pollution control audit was carried by certain references offered by it. Recently various fields have started developing a near field communication (NFC) a wireless technology accounting the importance of healthy society. It has been used in number of issues like ticketing, mobile payment and file sharing etc. Human health gets affected by air pollution and it get increased by trucks and cars like vehicles. So, there is need to propose a method for reducing it. So, with increase in use of NFC Mohsen YaghoubiSuraki, et.al, (2013), have described a new method that helps in prevention of air pollution and avoid driving offenses [20]. In their work they have used NFC technology for safe and easy transferring of information by considering the prevention of air pollution and avoiding traffic. The main motive was to provide a better use of new technology that enhances the health of society. To solve the transboundary air pollution control problem of china a rating charge model of transfer tax (RCTT) was established by Changmin Li, et.al, (2016) [22]. Firstly there were 31 china provinces, followers of China central government, leader in bi-level nonlinear programming model. In this the total nations pollutant control cost reduction was the objective of leader and each province balanced the pollutant reduction cost to minimize the pollution control costs. To fit the air pollutants environmental damage cost from 2003 to 2009 of Tianjin, Hebei and Beijing, by using the SO₂ reduction amount. Then on the basis of basic data a provincial territorial management model and RCTT model optimal solution were compared that shows a lowest cost was achieved in whole region and to control the transboundary air pollution, a cooperation of each administrative region was promoted. In Nakhon Ratchasima, Thailand, a medium sized starch factory, air pollution reduction analysis case study was presented by SudjitKaruchit, et.al,

(2018) [23]. The air pollution measurements, production processes, factory basic information and air pollution emission inventory were surveyed and data was gathered by them. Then at nearby receptors current pollutant levels were estimated using U.S.EPA's AERMOD air quality model along with possible pollutant reduction resulting from suggested clean technology options. The three groups of twelve options were produced by analysis that were improvement at Tapioca stockpile area, improvement at starch drying process and hot air generators improvement. The proposed model gives improvement in reduction of SO₂ concentration level and ambient dust by 30% and 44% respectively. The evaluation of proposed model showed that a factory's most appropriate options were 3 hot-air generators heat recovery economizers and bag filter system instalment. For reducing the air pollution impacts to its community, the evaluation was done with respect to environmental, economical and technical evaluation. Pollution caused due to automobiles and their real time solution was considered by S. Muthukumar, et.al, (2018), that was able to monitor the levels of pollution and reduce traffic in highly polluted areas [24]. To achieve it a sensor based hardware module was used by them that can be placed along roads or on the lamp posts. These modules wirelessly transfer the information about air quality to remote server that is further used for controlling traffic. The proposed system also provides information about air quality through mobile application that enables commuters to take up routes where air quality was good.

Table 2:Comparative study of various Air pollution Control Methods

Author name	Approach used	Motive of Work	Type of air pollution	Outcome
Xiaosong Gu, et.al., (2008)	IAQ control method for self-adaptive PID control theory based air-conditioned room	To increase human comfort and productivity	Continuous disturbances to indoor CO ₂ emission sources	By results evaluation it has been predicted that adaptive PID controller is more robust, has better control performance and gives faster dynamic response time as compared to single PID or fuzzy controller.
Diego Mendez, et.al, (2011)	P-Sense or pollution sense system	To allow international organizations, government officials and communities to have individual access to the pollution data for addressing their particular needs	-	The AQI of state, country or city was monitored and controlled by government officials and the respiratory problems of patients can be correlated by doctors according to the AQI exposed by them in their daily activities. This data can be used by realtors, country officials and community developers for

		and problem s.		determining the best place to build a new community or school.
Yaghou biSuraki, et.al, (2013)	They have proposed a new NFC based method that helps in prevention of air pollution and avoid driving offenses	Human health gets affected by air pollution and it get increased by trucks and cars like vehicles		In their work they have used NFC technology for safe and easy transfer of information by considering the prevention of air pollution and avoiding traffic. The main motive was to provide a better use of new technology that enhances the health of society.
Changm in Li, et.al, (2016)	A rating charge model of transfer tax (RCTT)	To solve the transboundary air pollution control problem of china	SO ₂ reduction	On the basis of basic data a provincial territorial management model and RCTT model optimal solution were compared that shows lowest cost was achieved in whole region
SudjittKauruchit, et.al, (2018)	U.S.EPA's AERMOD air quality model	To estimate current pollutant levels	SO ₂ concentration level and ambient dust	The proposed model gives improvement in reduction of SO ₂ concentration level and ambient dust by 30% and 44% respectively
S. Muthukumar, et.al, (2018)	Pollution caused due to automobiles	To monitor the levels of pollution and reduce traffic in highly polluted areas		These modules wirelessly transfer the information about air quality to remote server that is further used for controlling traffic. The proposed system also provides information about air quality through mobile application that enables commuters to take up routes where air quality was good.

6. CONCLUSION

In order to sustain healthy lives of humankind and those of the supporting ecosystems, there is need of clean air. Due to widespread industrialized growth there is release of various particulate matter and gaseous emissions that cause air pollution. In this review paper we have covered various

primary and secondary pollutants produced by human activities. Some of them are sulphur dioxide, Carbon monoxide, Chlorofluorocarbon, Ammonia, Ground level ozone, etc. This paper includes study on various causes and factors responsible for Air pollution. The most important aspect is its detection which has become must due to increase in amount of air pollution in the atmosphere that causes various health problems. Various researchers have proposed and used existing methods and approaches for detection of air pollution, along with detection measures, survey on various controlling methods are covered. Number of models have been proposed that proves to be helpful in detecting and controlling Air pollution and save human beings from various health issues.

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