

ARTICLE

DETERIORATING AIR QUALITY AND INCREASED HEALTH RISKS IN DELHI: THE DECISIONS BEING DELAYED

Avdesh Bhardawaj*, Gazala Habib, Annada Padhi, Abhishek Anand, Neeta Mahala, Badresh Kumar Singh

Department of Civil Engineering, Indian Institute of Technology Delhi, Hauz Khas, New Delhi, INDIA

ABSTRACT

Delhi is sitting on a virtual environmental health epidemic waiting to explode due to deteriorating air quality and related health effects. With about 80 deaths attributed daily to air pollution in the capital city of India, the menace is even higher than terrorism or natural disasters. Aerosols, especially PM_{2.5}, are responsible for major illnesses like respiratory problems, cardiovascular diseases, strokes, cancers and even deaths. The present study is a review of the existing air quality situation in Delhi, its causes and related health, environmental and socio-economic impacts. The focus is placed on chinks in the decision making process and critically examines avoidable delays that instigate losing scientifically gained grounds to political and bureaucratic lobbies. A historical perspective of events leading to the present status of the air quality and policies has been elucidated. The roles of different stakeholders like governments, judiciary, bureaucrats, NGOs, media and public pertaining to framing, implementing and sustaining related laws and policies have been discussed. Recommendations have been put forth for improving the air quality, monitor health aspects, develop strategies to combat related health effects, policy making and further research in the subject. The paper is expected to propound the current status of scientific research and related policies in air quality and health aspects in Delhi and offer viable solutions to tackle the problem posed as well as fill the gaps in policy development and implementation for improving the air quality and consequently health of the people.

INTRODUCTION

Air pollution has become a prominent avoidable reason of disease and death worldwide. It has emerged as one of the prime killers in recent times and the world's single largest environmental health risk. It has been ranked in top six as a major risk factor of morbidity and mortality consistently. Around 5.5 million people worldwide including 1.4 million in India die prematurely due to fine PM [1] or more commonly called as PM_{2.5} (Particulate Matter having aerodynamic diameter $\leq 2.5 \mu\text{m}$). Global Burden of Disease (GBD) report that came out in 2013 has ranked outdoor air pollution as the 5th biggest cause of death in India [2]. The report attributed around 6.2 lakh premature deaths per year due to air pollution induced illnesses, which is a six-fold escalation since year 2000. This translates into a staggering figure of about 71 deaths per hour or 1.18 deaths per minute. India has the dubious distinction of having half of the world's top 20 worst polluted cities from 3000 cities in 103 countries studied with Delhi at 11th Place in the list in terms of PM_{2.5} and 25th Place in terms of PM₁₀ [3]. Delhi's polluted air accounts for nearly 10 to 30 thousand deaths per year [4], which is about 80 deaths per day or 3.33 deaths per hour. On an average, Delhi's air kills more people annually there than terrorism or natural disasters.

PM_{2.5} penetrates deep into the lungs, bronchioles and alveoli and might get deposited there or pass on to the blood stream and be carried to different organs and cause various diseases like chronic bronchitis, COPD (Chronic Obstructive Pulmonary Disease), cancers of throat, lung and other organs, stroke and heart diseases like arrhythmia, ischemia, Heart Rate Variability (HRV), myocardial infarction etc. [5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16]. PM_{2.5} is regarded as the benchmark cause of air pollution induced morbidity and mortality by World Health Organization (WHO) [3]. As per GBD, 2013, ischemic heart diseases have claimed to be more fatal compared to respiratory diseases in India due to pollution from PM_{2.5} [2]. Particulate matter was categorized as carcinogenic and leading cause of human death by cancer by International Agency for Research on Cancer (IARC) in the year 2013 which is a specialized body of WHO [17]. Global Health Risks report [5] concluded that developing countries face more risk of such diseases than the developed countries. There has been a lot of concern regarding air quality in India and that has also resulted in the formation of an Air Quality Index (AQI) for India in the year 2015 to provide an indication of health risks due to criteria air pollutants.

Delhi has witnessed a consistent spurt in cardiovascular and respiratory diseases in Delhi of late, which are correlated with air pollution levels. Delhi's deteriorating air quality is ascribed to bio-mass burning, industrial exhausts and thermal power plants apart from vehicles. According to the official website of Delhi government [18] around 8.5 million vehicles ply on the roads with approximately 1,500 new vehicles adding to the woes and stress of air pollution in the city. The average life expectancy of Indians is being lowered by 3.2 years due to excess pollution [19]. In India, 660 million people now reside at places exceeding permissible PM_{2.5} concentrations. The urban poor, children and elders are the most vulnerable sections of the society in the context of air pollution's detrimental effects on health. This is so because children engage in a lot of outdoor activities like sports and also their breathing rates are higher during that time period. The poor section does not have facilities of air purifiers or hygienic conditions. The elderly are usually very prone to such diseases due to lower immunity and existing illnesses and medical histories. Hence policy makers must include the references and impacts on these vulnerable sections of the society while framing policies.

KEY WORDS

Aerosols; Delhi; health risk; cardiovascular illness; odd even scheme; PM_{2.5}

Published: 10 Oct 2016

*Corresponding Author

Email:
avdeshiitd@gmail.com
Tel.: +91-11-26597330
Fax: 91-11-26581117

ADVERSE HEALTH EFFECTS OF AIR POLLUTION IN DELHI

The preliminary symptoms of air pollution's adverse effects are seen on the eyes, skin, and cavities of the nose with sustained exposure leading to permanent impairments. Now with majority of high pollution causing factories having been put out of Delhi, air pollution is taken as a direct resultant of vehicular traffic, re-suspension, biomass burning, etc. The deterioration of air quality in Delhi is correlated to the number of vehicles, their design, maintenance, fuel quality, etc. The major share of vehicles in Delhi are propelled Delhi by twin-stage engines which exemplify seriousness of the situation and the reforms needed in the relevant policies. These engines being very inefficient have exhausts laden with dangerous smoke and particles that are inhaled by the people. In the 1980s, a lot of laws came into being in Delhi to tackle the menace of pollution but their effect was very limited on curbing Delhi's air pollution. In fact, air quality declined during this time period. This was so because even though there were environmental laws, but poor compliance neutralized all the gains.

Augmentation in certified deaths was seen from 11.4% to 20.4% and 3.8% to 4.6% owing to cardiovascular and respiratory illnesses respectively; both of which were directly linked to air pollution between 2006 and 2009 [20]. In the first half of 1990's decade, morbidity and mortality owing to heart and lung illness were allied to prevalent air quality and estimated to be more than 51,400 human lifetime years annually [21]. For certain age groups, especially the vulnerable section, a 0.23% intensification in per day deaths for every 10 $\mu\text{g}/\text{m}^3$ rise in total suspended particles was observed owing to such illness [21]. Respiratory problems have been seen more in people residing in more polluted zones in Delhi than cleaner ones [22, 23]. Greater pervasiveness of asthma indications was observed in school going kids who studied in schools close to traffic crossings [24, 25].

Increased air pollution as TSP in a time series analysis induced an increase in emergency room visits over a two-year period for asthma (by 21.3%), COPD (by 24.9%), and acute coronary events (by 24.3%) in AIIMS, a prominent government hospital in Delhi [26]. In another interesting study done at St Stephens Hospital Delhi, it was found that children aged 9 to 24 months living in proximity of elevated air pollution levels are at 54% greater chance of getting vitamin D insufficiency than those in cleaner environment [27] thus suggesting the role of air pollution in such cases. In 2007, a research found that pollutant concentrations will cross dangerous levels due to a surge in number of automobiles in Delhi and hence a cap on them is a must especially those running on diesel [28]. Asthma was detected in 7.7% of 3,500 children aged 7 to 15 in a four year study done in Delhi, suggesting higher pollution's role with asthma spurt [29]. An exposure-response study correlated indoor air pollution with a drop in lung functions of Delhi's children [30]. There has been a manifestation of effects of both outdoor and indoor pollution. Chittaranjan National Cancer Institute (CNCI) and Central Pollution Control Board (CPCB) did a study from 2002 to 2005 and concluded 43.5% of 11,628 school going kids in schools aged 4 to 17 years had reduced or limiting lung functioning [31] primarily attributed to air pollution exposure in Delhi.

National Capital Region Planning Board (NCRPB) found in 2009 that air pollutants concentrations Delhi and surrounding areas exceeded permissible limits [32]. Delhi saw significantly improved respiratory health for a short in years 2000 to 2002 owing to [33] switch over of CNG in commercial automobiles, and phasing out of factories from suburban areas. Symptoms of elevated respiratory disorder were observed among students living in different parts of Delhi [34, 35]. In 2012 CPCB published a detailed health study correlating air pollution with health effects [36]. According to its results, Upper Respiratory Symptoms (URS) were present in 21.5% and Lower Respiratory Symptoms (LRS) were 1.8 times greater in people of with Respirable Suspended Particulate Matter (RSPM) positively correlating to LRS. A third of Delhi's residents reported breathing issues with impaired pulmonary abilities and COPDs around 40 % and 4 % respectively. PM_{10} concentrations were a causative influence on high blood pressures which subsequently lead to heart related and neurological ailments. Investigation on the contents of polynuclear aromatic hydrocarbons (PAHs), in airborne particulate matter of Delhi revealed higher pollution in suburban zones here than those in other nations [35]. Source apportionment of air-borne contaminants for the duration of 19th Commonwealth Games held at New Delhi reported high contribution from vehicular pollution [37]. A study established that amending norms of usage in land area of Delhi rose air pollution significantly in the vicinity of Gurgaon, Noida, Faridabad and Ghaziabad [38]. In February 2015, Greenpeace carried out an air-quality monitoring survey in 5 schools throughout Delhi and concluded that $\text{PM}_{2.5}$ exceeded 4 and 10 times acceptable limits prescribed in India and by WHO respectively, with an average of 205.8 $\mu\text{g}/\text{m}^3$ [39].

CURRENT AND FUTURE PERSPECTIVES-SCIENCE AND POLICY

There have been some positive developments in India in the last two years since new government took over. In November 2014, Indian Prime Minister announced that air quality data would be made accessible to the public and new emissions standards will be set for power plants. India launched its Air Quality Index (AQI) on 6th April, 2015 which was based upon System of Air quality and weather Forecasting and Research (SAFAR). This gives a visual status of prevailing real time air quality and possible health impacts for even a layman to understand. It also predicts the air quality for the next day. This is an appreciable and positive step in the right direction. This would not only create awareness but also reduce exposure of people to dangerous air pollutants, and in the long run aid in meeting the requisite air quality standards. If the standards set by WHO could be met by Delhi, then majority of related

premature deaths can be avoided. Across India, annually 400 thousand premature deaths can be avoided if the WHO standards are satisfied [40]. This offers a gigantic challenge to rectify the situation. It is high time that scientific research and policy implementations work hand in hand.

RESPONSIBILITIES OF THE DIFFERENT STAKEHOLDERS

The onus of good health of the citizens is not the sole responsibility of the government; it is rather an agglomeration of efforts of a lot of stakeholders including judiciary, bureaucracy, NGO's, health care sector and the public at large.

Responsibilities of the government

The government has the responsibility of framing laws to control pollution and improve healthcare of the citizens. But this task can't be done in isolation. It involves the inputs from experts of a wide array of specialties including doctors, scientists, law professionals, etc. In India, the laws are framed so strict that they are hard to implement in practicality. Therefore, the need is to have not punitive but flexible and participatory laws to be framed. In the 1980s, the Indian Parliament passed numerous laws like Air (Prevention and Control of Pollution) Act 1981, for protecting the air we breathe. Formation of air pollution policy alarmed with rising pollution from a plethora of sources and reluctance on the part of the government to deal with this problem urged a famous environmental lawyer Mr. M. C. Mehta to approach the Supreme Court requesting protection of fundamental constitutional rights and to clean air in December 1985. The court directed ministries and departments in the government to implementation of the Air Act, 1981 in Delhi. Many more acts followed, including the Environmental (Protection) Act of 1986, Air Act (amended) 1987, Motor Vehicles Act 1988, and Central Motor Vehicle Rules 1989. The 1988 Motor Vehicles Act and the 1989 Central Motor Vehicle Rules empowered the government to set guidelines for vehicular emissions both for manufacturers as well as users in India. In 1993, the Ministry of Environment and Forests (MoEF) introduced the first set of standards regarding vehicular mass emissions for India. From 1994–1998, the Supreme Court vehemently worked towards implementation of three key reforms namely phasing out of gasoline with lead, premixed fuels and taking out commercial vehicles older than fifteen years off Delhi roads. The policies for leaded gas and premixed fuels after surmounting resistance from certain sections were ultimately adopted but the ban on 15-year-old commercial vehicles still hasn't seen the light of the day fully. Such a huge delay in implementation of laws does make a mockery of environmental system management and continues to diminish the air quality. Another failure on the part of the Delhi government was the creation of a Mass Rapid Transport System (MRTS) and Bus Rapid Transit (BRT) corridor. MRTS was conceived to lower the use of private vehicles and deal with the rising demand of transportation. The bypass was expected to reduce exposure to polluting trucks and buses that passed through Delhi. Owing to the faulty implementation of the designs and delays the BRT system is being dismantled and all the efforts gone into its making going into vain. Environment Pollution (Prevention and Control) Authority (EPCA) was established in 1998 and was authorized to consider policy and provide specific recommendations especially of technical nature to the courts. This has done some commendable work and has also been acknowledged by the Supreme Court of India. The ambitious scheme Odd-Even scheme of Delhi government has been more or less regarded as having insignificant effect on controlling air pollution levels [41, 42, 43, 44]. It is expected that the new central government with the motto of "make in India" would in all seriousness frame and implement the laws and policies to arrest the spurt in air pollution level and health impacts particularly in the capital city of the country-Delhi.

Responsibilities of the Judiciary

Judiciary has multiple responsibilities in the context of air pollution norms. In the absence of the government taking a lead in the implementation of the laws, the judiciary has the authority in India to issue orders to the government. In Indian society, it is perceived to be an autonomous and comparatively less corrupted guardian of fundamental rights. The courts are also supposed to hear grievance cases in the non-implementation or wrongful prosecutions in some cases, providing relief and reparations for indemnity to people, property and associated matters. The first intrusion by the Apex court in India, the Supreme Court was in early 1990 to forcibly relocate hazardous, heavy, toxic and big polluting category "H" industries from Delhi according to the second master plan for Delhi accepted by the then central government in 1990 [45]. But with government's laxity and strong industrial lobby many deadlines passed yet the industries remained at their locations in Delhi. With perseverance of the Court though, these industries were finally relocated out of Delhi by 1997. The nexus of some political sections and industries is one of the stumbling blocks in strict decision making. Then a historic Apex Court judgment in 1998 forced every community level transport automobiles in Delhi to use Compressed Natural Gas which lowered RSPM levels significantly, although in due course of time, all the improvements in air quality levels have been dissipated. In the year 1995 mean RSPM level in Delhi was 409 $\mu\text{g}/\text{m}^3$ which reduced upto 190 $\mu\text{g}/\text{m}^3$ and 160 $\mu\text{g}/\text{m}^3$ in the years 2000 and 2007 respectively but in a 2016 report by WHO, it stands at 225 $\mu\text{g}/\text{m}^3$ which is about 6 times the safe limit of WHO [3]. Herein raises the question as to what caused such loss of covered ground so quickly. The answer lies in the delays of the decisions to be implemented. In India a dedicated Nation Green Tribunal (NGT) was formed in the year 2010 to speedily deal with all cases pertaining to environment, including air pollution and to reduce the burden of litigation in the higher courts. A recent case in point is National Green Tribunal's (NGT) direction to prohibit petrol

and diesel vehicles older than 15 and 10 years respectively from plying in Delhi and surrounding areas. This has been in controversy for past some time because a section of the government is concerned with specific lobby and giving reference of public and essential services as a scapegoat. But the Supreme Court is welcoming the ban as are the scientific experts. But in the meantime while the decision is being taken, the delay is already caused and gained grounds are lost. Courts also perform an important role in law enforcement. The toll on heavy and light diesel trucks plying through Delhi at night will be imposed from November 1, 2015 to check the high PM levels due to their exhausts. This order has come directly from the Supreme Court of India. There has been a welcome positive progress in the attitude of the judiciary towards environmental decision making process. In India, penalties for pollution are in fact so severe that they are hardly ever enforced. The delays will hopefully be avoided henceforth and political or electoral commitments shouldn't dilute the scientific achievements.

Responsibilities of the bureaucracy

The bureaucracy is a vital cog in the entire scheme of decision making and execution of environmental decisions and policies. They act as a connecting link between the government policies and ground level accomplishments. This link has traditionally been the one where the decisions were mostly delayed, but of late the pressures of the media and stricter governance have made this important area smoother functioning and less corrupt. A lot of cases are seen in the media where the bureaucrats take a lead in championing the environmental causes. If this aspect of governance can take a lead in faster execution of environmental plans then a major part of the entire delay can be avoided and better management achieved.

Responsibilities of the NGOs

The courts also act with the vigilant eyes of an active NGO community in India that continues to give unbiased views and at the ground level suggestions, keeping the entire system on their toes. The contribution of NGO's in the environmental systems decision making in India has been phenomenal. Apart from creating awareness among the masses regarding environmental issues and working out projects, these NGO's keep relentless pressure on the authorities to execute the plans and laws. In Delhi the contribution of NGO's like Centre for Science and Environment (CSE) and environmental lawyers filing Public Interest Litigations (PIL) have been instrumental in keeping the work going. An illustration of this is the complete ban on blue line buses from Delhi roads. The role played by media including newspapers (press), magazines, television, and radio. With the advent of social media the potential role of sites like Facebook and WhatsApp has increased considerably. With signature movements to file petitions becoming common online, it appears to be start of an upcoming digital environmental protection age. The ultimate responsibility of health remains with the people at large. It is their task to avoid pollution, pressurize governments to take actions to regulate environmental standards and take precautions to minimize exposure. The recent initiatives like *Raahgiri days* (Pedestrian's days) in Delhi and Gurgaon is a welcome step where no traffic is allowed on specified and notified roads and these are dedicated towards fun activities, street plays, awareness campaigns, safety trainings, etc. Similar scheme in Gurgaon having car free days every Tuesday has seen some positive change coming to public life.

CONCLUSION

It can be concluded that the gains of scientific knowledge, experiences of epidemiological studies and the efforts put in by different stakeholders are neutralized and sometime buried by political inaction, bureaucratic apathy and vested interests. This has turned Delhi's air into slow breathing poison and the stage is being set for a major public health disaster waiting to happen. It is high time that tough decisions be made and strictly implemented quickly without any delay for improving air quality in Delhi and saving millions of lives.

RECOMMENDATIONS: THE ROAD AHEAD

The National Ambient Air Quality Standards (NAAQS) should be made legally binding in all regions with hefty penalties for any violations. The implementation of a color coded Air Quality Index (AQI) with health advisories (now available only for ten cities in India) should be implemented at all places in India because air pollution is rarely a confined or local issue as the polluted air from a surrounding area like Gurgaon, Ghaziabad or Noida can easily affect Delhi's air and health of its people. As soon as possible, switching should be done to Euro V and Euro VI standards. Curb must be exercised on diesel vehicles as diesel is now regarded as class I cancer causing agent by WHO. Until then diesel retro fitment must be done on such vehicles. Subsidies and policy assistance must be extended to swop to CNG, battery operated vehicles non-motorized transport and other relatively cleaner modes of transport. Public transport like buses and metro rails should be extended to reach out to entire population so as to reduce dependence on private vehicles. Lead-free fuel should be made easily available, all polluting vehicles regardless of its age should be banned, and stricter parking norms must be evolved along with to signal-free roads. With the availability of a lot of health cost estimation models proper estimation of illnesses caused by air pollution should be an integral part in decision making. Media and specially social media which has deep penetration and reach should be involved in creating awareness and educating the masses regarding this

important issue and pollution emergencies measures on the same lines as disaster management plans. Polluter's pay principle must be implemented in the strictest possible means to act as deterrent for defaulters. Possibilities in Clean Development Mechanism (CDM) must be explored in this area. Majority of Delhi's premature non-accidental deaths can be avoided by taking precautionary steps in controlling air pollution to come within national ambient air quality and WHO standards. Epidemiological studies have confirmed PM_{2.5} as the most harmful air pollutant for health effects hence its regular monitoring must be done at all places. Starting immediately, all children in Delhi should undergo lung function test, blood pressure monitoring and ECG at least once in a year, and those detected with problems must be monitored regularly. This must be recorded with air pollution data of that place. Subsequently, this should be extended to all citizens and data maintained and analyzed scientifically on regular basis to evolve policies. Mass transit, pedestrian walking zones, and bicycle lanes should be included in all city and township planning. Above all, the decisions pertaining to environment must not be delayed for the road ahead to development is a bumpy and challenging one.

CONFLICT OF INTEREST

All the authors declare no conflict of interest whatsoever.

ACKNOWLEDGEMENTS

None

FINANCIAL DISCLOSURE

All the authors declare no conflict of financial interest.

REFERENCES

- [1] Brauer M. [2016] The Global Burden of Disease from Air Pollution. In: 2016 AAAS Annual Meeting (February 11-15, 2016).
- [2] Global Burden of Disease (GBD) Report, 2013. Available at: http://www.healthdata.org/sites/default/files/files/policy_report/2013/GBD_GeneratingEvidence/IHME_GBD_GeneratingEvidence_FullReport.pdf.
- [3] Global Urban Ambient Air Pollution Database (update 2016). Available at: http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/
- [4] Apte JS, Marshall JD, Cohen AJ, Brauer M. [2015] Addressing global mortality from ambient PM_{2.5}. *Environmental science & technology* 49(13): 8057-8066
- [5] Brunekreef B, Hoffmann B. [2016] Air pollution and heart disease. *The Lancet*.
- [6] Ierodiakonou D, Zanobetti A, Coull BA, Melly S, Postma DS, Boezen HM, Hallstrand TS. [2016] Ambient air pollution, lung function, and airway responsiveness in asthmatic children. *Journal of Allergy and Clinical Immunology* 137(2): 390-399.
- [7] Kaufman JD, Adar SD, Barr RG, Budoff M, Burke GL, Curl CL, Kronmal R. [2016] Association between air pollution and coronary artery calcification within six metropolitan areas in the USA (the Multi-Ethnic Study of Atherosclerosis and Air Pollution): a longitudinal cohort study. *The Lancet*.
- [8] Tsangari H, Paschalidou AK, Kassomenos AP, Vardoulakis S, Heaviside C, Georgiou KE, Yamasaki EN. [2016] Extreme weather and air pollution effects on cardiovascular and respiratory hospital admissions in Cyprus. *Science of the Total Environment* 542:247-253
- [9] Halonen JI, Blangiardo M, Toledano MB, Fecht D, Gulliver J, Anderson HR, Tonne C. [2016] Long-term exposure to traffic pollution and hospital admissions in London. *Environmental Pollution* 208: 48-57.
- [10] To T, Zhu J, Larsen K, Simatovic J, Feldman L, Ryckman K, Villeneuve PJ. [2016] Progression from Asthma to Chronic Obstructive Pulmonary Disease (COPD): Is Air Pollution a Risk Factor? *American journal of respiratory and critical care medicine*, (ja).
- [11] Nascimento LFC, Vieira LCP, F Mantovani KCC, Moreira DS. [2016] Air pollution and respiratory diseases: ecological time series. *Sao Paulo Medical Journal*, (AHEAD), 0-0.
- [12] To T, Zhu J, Villeneuve PJ, Simatovic J, Feldman L, Gao C, Miller AB. [2015] Chronic disease prevalence in women and air pollution—A 30-year longitudinal cohort study. *Environment international* 80:26-32.
- [13] Diaz-Sanchez D. [2015] Can particulate pollution affect lung function in healthy adults? *American journal of respiratory and critical care medicine* 191(6): 610-612.
- [14] Shrey K, Suchit A, Deepika D, Shruti K, Vibha R. [2011] Air pollutants: the key stages in the pathway towards the development of cardiovascular disorders. *Environmental toxicology and pharmacology* 31(1):1-9.
- [15] Mills NL, Donaldson K, Hadoke PW, Boon NA, MacNee W, Cassee FR, Newby DE. [2009] Adverse cardiovascular effects of air pollution. *Nature clinical practice Cardiovascular medicine* 6(1): 36-44.
- [16] Brook RD. [2008] Cardiovascular effects of air pollution. *Clinical science*, 115(6): 175-187.
- [17] Loomis D, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V, Benbrahim-Tallaa L, Straif K. [2014] IARC evaluation of the carcinogenicity of outdoor air pollution. *Environnement, Risques & Santé*, 13(4): 347-352.
- [18] Delhi govt. (2015) Total Vehicle registration. Available at: http://delhi.gov.in/wps/wcm/connect/doit_transport/Transport/Home/Vehicle+Registration/Total+Vehicle+Registered.Accessed:14/October/2015.
- [19] Greenstone M, Nilekani J, Pande R, Ryan N, Sudarshan A, Sugathan A. [2015] Lower pollution, longer lives life expectancy gains if India reduced particulate matter pollution. *Economics and Political Weekly* 8: 40-46.
- [20] DoES, [2010] Annual Report on Registration of Births and Deaths in Delhi. Directorate of Economics and Statistics, Government of Delhi, New Delhi, India.
- [21] Cropper ML, Simon NB, Alberini A, Arora S, Sharma PK. [1997] The health benefits of air pollution control in Delhi. *American Journal of Agricultural Economics* 1625-1629.
- [22] Chhabra S K, Chhabra P, Rajpal S, Gupta RK. [2001] Ambient air pollution and chronic respiratory morbidity in Delhi. *Archives of Environmental Health: An International Journal* 56(1): 58-64.
- [23] Rajkumar P. [1999] Effect of air pollution on respiratory system of auto rickshaw drivers in Delhi. *Indian Journal of Occupational and Environmental Medicine* 3(4):171-3.
- [24] Paramesh H. [2002] Epidemiology of asthma in India. *The Indian Journal of Pediatrics* 69(4):309-312.
- [25] Chhabra SK, Bhatnagar S. [2002] Bronchodilator Responsiveness in Asthma Chronic Obstructive Pulmonary Disease c. *Indian J Chest Dis Allied Sci* 44:91-971
- [26] Pande JN, Bhatta N, Biswas D, Pandey RM, Ahluwalia G, Siddaramaiah NH, Khilnani GC. [2002] Outdoor air pollution and emergency room visits at a hospital in Delhi. *Indian Journal of Chest Diseases and Allied Sciences*, 44(1): 13-20.
- [27] Agarwal, KS, Mughal MZ, Upadhyay P, Berry JL, Mawer EB, Puliylal JM. [2002] The impact of atmospheric pollution on vitamin D status of infants and toddlers in Delhi, India. *Archives of disease in childhood* 87(2):111-113.
- [28] Mohan M, Kandya A. [2007] An analysis of the annual and seasonal trends of air quality index of Delhi. *Environmental monitoring and assessment* 131(1-3):267-277.
- [29] Rajkumar, Jitendra K Nagar, Harsh Kumar, et al.[2007] Association of indoor and outdoor air pollutant level with respiratory problems among children in an industrial area of

- Delhi, India. Archives of Environmental & Occupational Health 62 (2); 75-80.
- [30] Rajkumar, Jitendra K. Nagar, Alka Singh Kushwah, Neelima Raj, Mahesh Meena, SN Gaur. Indoor air pollution and respiratory fun 20(1): 36 48.
- [31] CPCB [2008] Study on ambient air quality, respiratory symptoms and lung function of children in Delhi.
- [32] NCRPB. [1999] A Report on National Capital Region Growth and Development.
- [33] Foster A, Kuma, N. [2011] Health effects of air quality regulations in Delhi, India. Atmospheric Environment 45(9):1675-1683.
- [34] Mathew J, Goyal R, Taneja KK, Arora N. [2012] Correlation between Air Pollution and Respiratory Health of School Children in Delhi. 2nd WAO International Scientific Conference (WISC 2012) pp. 16.
- [35] CPCB. [2012] Epidemiological study on effect of air pollution on human health (adults) in Delhi.
- [36] Khillare PS. [2013] Investigation on the contents of polynuclear aromatic hydrocarbons (PAHs), in airborne particulate matter of Delhi.
- [37] Marrapu P, Cheng Y, Beig G, Sahu S, Srinivas R, Carmichael GR. [2014] Air quality in Delhi during the Commonwealth Games. Atmos. Chem. Phys, 14, 10619-10630.
- [38] Kumar N, Linderman M, Chu A, Tripathi S, Foster AD, Liang D. [2014]. Environmental Interventions and Air Pollution (Re) distribution in Delhi, India. India (June 8, 2014).
- [39] S Greenpeace [2015] Delhi children breathe toxic air. Available at: <http://www.greenpeace.org/india/en/Press/-Delhi-children-breath-toxic-air-reveals-Greenpeace-air-monitoring-survey-in-schools/>
- [40] Hoy D, March L, Brooks P, Blyth F, Woolf A, Bain C, Buchbinder R. [2014] The global burden of low back pain: estimates from the Global Burden of Disease 2010 study. Annals of the rheumatic diseases, annrheumdis-2013.
- [41] Sehgal M, Gautam SK. [2016] Odd even story of Delhi traffic and air pollution. International Journal of Environmental Studies 73(2): 170-172.
- [42] Gupta M, Raheem S. [2016] Delhi Air Pollution–A Review. Journal of Environmental Engineering and Studies, 1(1).
- [43] Pavani VS, Aryasri AR. [2016] Pollution Control through Odd-Even Rule: A Case Study of Delhi. Indian Journal of Science, 23(80):403-411.
- [44] Jha S. [2015] Oddity of Managing Air Pollution in Delhi: Public Policy Myopia. Apeejay School of Management–Centre for Public Policy & Governance Discussion Paper, 1.
- [45] Bell RG, Mathur K, Narain U, Simpson D. [2004] Clearing the air: how Delhi broke the logjam on air quality reforms. Environment: Science and Policy for Sustainable Development, 46(3): 22-39.