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Research Article

A GLOBAL PERSPECTIVE OF VEHICULAR EMISSION CONTROL POLICY AND PRACTICES: AN INTERFACE WITH KATHMANDU VALLEY CASE, NEPAL

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ABSTRACT

Transport sector is growing most rapidly around the world in line with the urban and socio-economic growth, which is contributing to severe air pollution. Air pollution has been of much concern mainly due to air quality, human exposure, public health, climate change, and visibility reduction. At present, in the media and policy arena, significant attention is given to the transport air pollution and its effect. Although most of the developed countries established vehicular emission control practices, it is very primitive in the developing countries including Nepal. This paper highlights global policies/legislations that have been practiced for emissions control from high emitting vehicles based on the available literature. The insights and lessons based information presented in this paper will add value to the policy makers for creating strong policy packages of air quality management for Kathmandu valley including other parts of Nepal.

Keywords: Transport sector, Vehicular emissions, Air quality, Policy, Emissions control

INTRODUCTION

The world urban population has increased about fivefold in between 1950 to 2011 (i.e., passing from 0.75 billion to 3.6 billion) (UN 2012). Likewise, motor vehicle activity is growing rapidly (Aggarwal & Jain 2014, Badami 2004, Badami 2005). By 2040, world's population is expected to become nine billion. Therefore, the demand of energy is expected to grow by 30 percent from 2016 to 2040 (ExxonMobil 2013). Air quality around the world is found to be deteriorating and vehicular emissions is one of the main sources (Guo *et al.* 2016). The increase in vehicular emission is because of growing population, urbanization and socio-economic development (Wu *et al.* 2017, Guo *et al.* 2016). High fuel consumption from on-road vehicles emits greenhouse gases like carbon dioxide (CO_2), nitrous oxides (N_2O), methane (CH_4) and other harmful pollutants such as hydrocarbon (HC), particulate matters (PM), oxides of nitrogen (NO_x) and sulfur dioxide (SO_2) (Wu *et al.* 2017, Ribeiro *et al.* 2007, Kathuria 2004, Garg *et al.* 2006, Neeft *et al.* 1996, Raux 2004). Transport sector contributed 23 % of the world's CO_2 emissions and 74 % on-road CO_2 emissions in 2004 (Ribeiro *et al.* 2007). This data is closer to Chapman (2007), which reveals 26 % of the global CO_2 emissions. More emission prevails due to old and lack of adequate maintenance of road vehicles, high traffic congestion, fuel adulteration and poor road infrastructure. Although heavy-duty diesel vehicles (HDDV) represent lesser proportion, their emissions contribute significantly to air pollution problems (Kirchstetter 1999). Road vehicle emission also has been partly contributing for acid deposition, stratospheric ozone depletion and climate change (Shrestha 2018). The developed countries adopted strong legislation to reduce the automobile emissions and enhancing better air quality (Zhang *et al.* 1995). However, it is very primitive in the developing countries including Nepal. Vehicular emissions if uncontrolled may lead to increased level of health effects (e.g., respiratory disease, heart disease, cerebro-vascular disease, chronic obstructive pulmonary diseases, lower respiratory infections, and cancers) (Guttikunda *et al.* 2014, Neeft *et al.* 1996, Raux 2004) and can exacerbate local/regional warming because CO_2 and BC emissions have a high global warming potential (Das *et al.* 2018, Chapman 2007, Faiz 1993).

Due to rapid increase in vehicles registration (i.e., 13.8 % per year) at present (DoTM 2012), daily traffic number must have significantly increased. Therefore, it is reasonable to state that at present vehicles are the major sources of air pollution too in the Kathmandu valley. From 1989 until April 2015, 1,957,849 vehicles have been registered in Nepal. Out of which, 818,484 (42 %) vehicles was registered in Bagmati zone (DoTM 2015). Motorcycles occupies a large share (75 %) of Euro III technology, whereas, other vehicles (< 25 %) are Euro II or lower (Shrestha *et al.* 2013). The diesel fuel consumption in Kathmandu valley in 2012 was 15.46% of the total diesel consumption in Nepal (NRB 2012). This paper presents global policies and practices of vehicular emissions control. The lessons learned from other countries will add value to the policy review for better air quality management for Kathmandu valley and other parts of Nepal.

MATERIALS AND METHODS

Plethora of studies on policies context on vehicular emission control are available worldwide. The published literature of motor vehicles emission control in Asian countries (e.g., China, India and Nepal) as well as developed countries (e.g., United States and Europe) were thoroughly reviewed and incisively analyzed. International strategies and activities governments are undertaking to control emissions at present were deeply explored and compared among the countries. The national strategy and activities Government of Nepal currently being undertaken were also assessed. The policy gaps for Nepal were identified through papers review. Policy recommendations for vehicular emission control for Kathmandu valley were presented based on the scientific evidences, legislations, and practices adopted by developed and developing counties.

RESULTS AND DISCUSSION

Vehicle emission standard

China implemented emission standards and better fuel quality standards before 2000 to control vehicular emission. Later, the standards tightened in every 3 to 5 years. In just less than 13 years, China 1 (i.e., equivalent to Euro I) to China 5 (i.e., equivalent to Euro V) standard was formulated. To prevent from tampering behavior of the vehicle users, China amended the emission standard together with harsh penalties (Wu *et al.* 2017). Beijing was a pioneer in controlling the vehicular emissions (Wu *et al.* 2011). Realizing the vehicular emissions as one of the major sources and improving the air quality, China's state council was implemented air pollution prevention action plan in 2013 (SC 2013). The emission standard for HDDV for China 5 stage were 4.0 g/kWh CO, 0.55 g/kWh HC, 2.8 g/kWh NO_x, and 0.03 g/kWh PM (ICCT 2014). In India, government recently set up Bharat Stage (BS)-IV norms for vehicle emissions control. The maximum permissible limits for HDDV were 1.5 g/kmhr CO, 0.96 g/kmhr HC, 3.5 g/kmhr NO_x and 0.02 g/kmhr PM. However, BS III norms were 2.1 g/kmhr CO, 1.6 g/kmhr HC, 5.0 g/kmhr NO_x and 0.10 g/kmhr PM (CPCB 2017). Similarly, Europe strictly tightened the emission standard for heavy duty vehicles in the short span of time. The emission standards for NO_x for Euro I, Euro II, Euro III, Euro IV, Euro V and Euro VI were 8 g/km, 7 g/km, 5 g/km, 3.5 g/km, 2.0 g/km and 0.4 g/km respectively (Vestreng *et al.* 2009). Likewise, in United States, at present emission standards for heavy duty highway vehicles (Spark-Ignition) are 0.195-0.230 g/mi NMHC, 0.2-0.4 g/mi NO_x, 0.02 g/mi PM, and 7.3-8.1 g/mi CO depending upon the vehicle weight (USEPA 2016).

In Nepal, Environmental Protection Act-1997, National Ambient Air Quality Standard, NAAQS-2012 and Climate Change Policy-2011 were developed after realizing the need of better environment. However, those policies do not elaborate in-depth and clear picture for vehicular emissions control strategy. Nepal initiated activities for monitoring of exhaust emissions in the Kathmandu valley in 1993 and issuance of Green Sticker system was enforced since December 1999. Later, Nepal Vehicle Mass Emission Standard, NVMES-2000 was introduced and was again revised in 2012. For light duty diesel vehicles (LDDV) (< 2.5 tons), the upper permissible limit values (g/kWh) for passenger cars were 0.64 CO, 0.56 (HC+NO_x), 0.5 NO_x, and 0.05 PM. Similarly for LDDV (> 2.5 and < 3.5 tons), the permissible limit values (g/kWh) were 0.64-0.8 CO, 0.56-0.86 (HC+NO_x), 0.5-0.78 NO_x, and 0.05-0.1 PM. For diesel vehicles (> 3.5 tons), the upper permissible limit values (g/kWh) were 2.1 CO, 0.66 HC, 5.0 NO_x, and 0.10-0.13 PM (MoEST 2012). However, these tests have not been operated in Nepal yet. DoTM adopts smoke opacity test (SOT) for diesel vehicles in idling condition only. In general, the SOT for diesel vehicles is 2.5 per meter (naturally aspirated) and 3.0 per meter (turbo charged). According to Faiz *et al.* (2006), the smoke density for diesel vehicles ranges within 65-75 Hartridge Smoke Unit (HSU), as per the vehicle condition. The vehicle emission testing is only limited within Kathmandu valley and is applicable only to three and four wheelers.

Vehicle restriction

China has implemented an environmental labeling policy to mark high emitter vehicles. The yellow labels were marked for pre-China III HDDV. These vehicles were restricted to larger areas (e.g., Shanghai, Guangzhou, Shenzhen, and Hangzhou) after the release of the Action Plan in 2013 (Wu *et al.* 2016). In Europe, many countries (e.g., Austria, Denmark, Germany, Netherlands, and Sweden) have developed a low emission zone framework/legislation within the last decade (Holman *et al.* 2015). This is quite similar to yellow-labeled vehicles restricted to larger cities of China. Recently in Kathmandu valley, heavy duty vehicles were restricted to drive inside ring-road during the peak hours; however, the problem still persisted in the ring road as it lie close proximity to the main market centers.

Inspection and maintenance

China released a national regulation for inspecting and measuring on-road high emitting diesel vehicles using remote sensors (Ministry of Environmental Protection-China 2017). Vehicles inspection and maintenance practices have become successful in Gothenburg, Sweden too. The emission reduction performance was found better than Los Angeles, California and Melbourne (Zhang *et al.* 1995). DoTM is the sole organizations to conduct vehicle emission test in Nepal. Vehicle inspection is required once a year except commercial vehicles, which has provision to test every six months. To obtain a green sticker, it is crucial to pass the test and not allow the failed vehicles to operate in the Kathmandu valley. To pass the emission test, vehicle owner opt maintenance services. For road side emission check, only nominal penalty is charged for the failed vehicles. It was reported a decade ago that about 33-40 % of the diesel vehicles emissions can be reduced after proper maintenance (Faiz *et al.* 2006). However, there is lacks of vehicle maintenance policy in Nepal and the inspection as well as the emission test system has not been effectively implemented.

Fuel quality

China is currently promoting improved fuel quality as well as alternative fuels. The upper permissible limit of sulfur content in diesel vehicles was reduced from 2000 ppm (Euro 0) to 50 ppm (Euro IV) (Cai & Xie 2013, Cui *et al.* 2017). In India, SO_2 emissions have been found to be reduced greatly in the transport sector. This is due to the successive reduction of sulfur content [Bharat Stage (BS) III- 350 ppm and BS IV- 50 ppm] specification used in diesel vehicles imposed by fuel quality standard (Guttikunda *et al.* 2014, Amann *et al.* 2017). In Europe, in early 2000, maximum diesel sulfur permissible limit was 350 ppm. Later in 2005, the sulfur content was dropped to 50 ppm. The current guideline for diesel sulfur is 10 ppm (Euro VI) (ICCT 2016). Nepal Oil Corporation started supplying EURO III standard fuel since 2010. Maximum upper limit value of sulfur is 350 mg/kg of diesel (BS III) for Nepal.

Higher engine technology

China has made a progressive advancement in the Engine Technology from Euro III to Euro IV, switching towards electric vehicles, EV (Cai & Xie 2013, Cui *et al.* 2017) and Euro V vehicles in just short period of time. In India, policy has been developed to cut off vehicular emissions from HDDV. As per Supreme Court order, from 2002 onwards all buses were transformed to compressed natural gas, CNG in Delhi (Kathuria 2004). Later, the policy formulated two parallel standards such as BS IV for 11 major cities (Amann 2017) and BS III, for rest of the country. However, this policy did not address the consumers and businesses outside of the major cities equitably. All heavy duty trucks complied BS III standard only, and fuelling stations requiring low sulfur were also not accessible everywhere. Therefore, it is reasonable to say nothing prevents BS IV vehicles refueling in high-sulfur fuel area (ICCT 2013). Ministry of Road Transport and Highways of India decided to deploy Euro VI vehicles from 2020 onwards (Amann, 2017). In Europe, Euro VI has been implemented from 2014 to cutoff vehicular emissions (ICCT 2016). Realizing the issues of air pollution in the Kathmandu valley and to alleviate it, Government of Nepal banned the operation of highly polluting three wheelers diesel vehicles as well as import new two-stroke and second hand vehicles from 1999 onwards. Moreover, from 2000 onwards, government of Nepal promulgated to phase out 20 years old vehicles (Faiz *et al.* 2006). Those above factors have initiated scaling up of EV (e.g., Safa tempo) for public transportation. At present, all vehicles except HDDV imported to Nepal require compliance with EURO III emission standard.

Subsidy, tax exemptions and scrappage of high-emitting vehicles

To enhance EV sales, save energy and reduce vehicular pollution, subsidies and tax exemptions have been applied by the local and central Government of China. The scrappage program was launched to phase out yellow-labeled vehicles through proper subsidies/incentives. In this regard, Beijing has released a plan to cut off older vehicles (Wu *et al*. 2011). Similarly, Europe provides huge subsidies and greatly reduced tax to promote EV sales. In Norway, the excise tax reduction ranged from 39 % to 67 %. The Netherlands, France and UK excise tax reduction ranged from 10 % to 40 % (EC 2017). Decades ago, Nepal Government had provision to increase EV by waving custom duty and sales taxes. The policy makers and donor communities were interested to promote it in the Kathmandu valley (Dhakal 2003). Despite that, no strong initiative has been taken strategically and neither Government of Nepal has developed concrete plan of subsidies and reduction of excise tax to promote EV sales.

CONCLUSION

To minimize the vehicular air pollution, revision of emission standards of CO_2, NO_x, PM, CO, and HC of high emitting vehicles of Nepal are crucial. It should be based on the real- emission measurement work. Moreover, SOT should also be revised as mentioned above. In order to identify gross polluting vehicles in the Kathmandu valley, the application of remote sensing devices is crucial as in China. Using the device, traffic police can conduct on-road side emission test to get the real picture of vehicular performance. Likewise high emitting on-road vehicles should be seriously penalized. To assist in the identification of gross polluters in the Kathmandu valley, individuals can send SMS or text message to DoTM or traffic division from their mobile phones to report sightings of smoke belching vehicles. This approach was successful in Metro Manila. DoTM or traffic divisions may take action on vehicle owner for formal testing upon having such policy developed. Vehicle restriction strategy has not been effectively working in the Kathmandu valley. The problem of traffic jam and high emissions still persist around the main market centers in close proximity to the ring road. This issue must be addressed through study based policy. The vehicular inspection and maintenance policy can be one of the low cost options to reduce the emissions up to 40 % as per Faiz *et al.* (2006) findings. The inspection and maintenance policy should be developed for old model commercial vehicles as well. In order to maintain the fuel quality standard, timely inspection and fuel test of petrol pumps are essential. Moreover, technological change may play prodigious role in lowering the vehicular emissions. Government of Nepal should deploy advanced technology (e.g., Euro IV and higher models vehicles) as well as provide high subsidies and tax exemptions to promote EV sales. The scrappage of high emitting vehicles program can be other options for the Kathmandu valley through proper incentives from the government. To achieve better air quality or effective low carbon transport plan, development of comprehensive vehicular emission control polices and strategies are foremost steps for Nepal.

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