EVALUATION OF IN - VEHICLE VOCs FROM MASS TRANSPORTATION – A REVIEW

[1]Mousmi Thumber, [2] Dr. Minakshi Vaghani

[1]Student of Master of Environmental Engineering, [2]Assistant Professor in Environmental Engineering Department
[1] Department of Environmental Engineering,
[1]Sarvajanik College of Engineering & Technology (SCET), Surat, India

Abstract: Sustainability of urban advancement is enormously influenced by quick rate development of Urbanization. Transportation framework is key component of any urban advancement. So as to manage traffic issues, mass transportation or open transport is most helpful choice. It is important to screen the air quality winning inside the vehicle as travelers are straightforwardly presented to it for voyaging hours. Endeavors are being made to assess and review the In-vehicle outflow from open transports. Unpredictable Volatile Organic compounds (VOCs) are viewed as normally expected in In-vehicle contaminations. VOCs like Benzene, Toluene, Ethylbenzene and Xylene (BTEX) is reviewed from in-house territory of mass transports. The present investigation means to break down the research gaps for In-vehicle VOCs from mass transports.

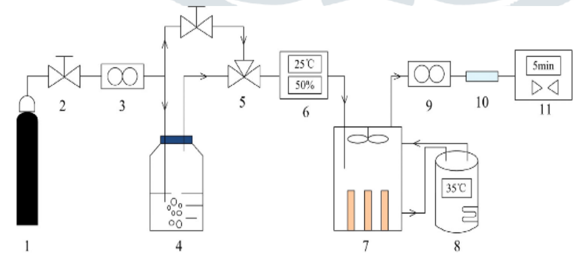
***Index Terms* - BTEX compounds, In-vehicle monitoring, VOC analyzer**

I. INTRODUCTION

Contamination is characterized as the troublesome modification of our environment. It changes the nature of air, water and land which causes wellbeing impact on people and other life on earth. The biodegradable toxins break down quickly and non-biodegradable poisons don't disintegrate in the environment. Corruption of nature has become a significant issue. Among different contamination, Air contamination causes considerable antagonistic effect on human wellbeing and the encompassing condition, especially in the developing nations and rising economies like India. Long haul presentation of different air toxins, for example, Suspended Particulate Matter (SPM), Irrespirable Suspended Particulate Matter (RSPM), Nitrogen Dioxide (NO_2), Sulphur Oxides (SO_x), Volatile Organic Compounds (VOCs), and different harmful gases causes wellbeing risk. Separated of open Air Pollution, Indoor Air contamination have demonstrated unfriendly effect on human wellbeing on long haul introduction lately. Individuals spend a huge bit of their in vehicles, so in-vehicle air quality will fundamentally fall apart the general population's wellbeing. Indoor Air contamination and In-Vehicle air contamination is a risk to the general population investing more energy inside their home and inside the vehicular chamber. Indoor air contamination is brought about by the paints utilized in divider painting, Polishing paint utilized in Furniture, Various cowhide materials utilized in inside. In vehicle air contamination is brought about by Paints utilized in autos, Busses, Materials utilized in Seat spread, Carpets utilized in Cars, Steering materials. The significant contaminations in-entryway and in-vehicle are VOCs. There are scope of VOCs and Benzene, Toluene, Ethyl-Benzene, Xylene (BTEX) are the most risk causing.

II. REVIEW METHODS

The very common method for the sampling of VOCs from atmosphere is by using sorbent tubes made up of various absorbing or adsorbing material such as charcoal, coconut husk, these tubes are tenax thermal adsorption tubes. Most of the article referred indicated this method due to its accuracy but this method is a bit time consuming and not so economical though being a conventional method.



1) Gas cylinder, 2) valve, 3) flow controller, 4) wash bottle, 5) 3 way valve, 6) temperature & humidity sensor, 7) ventilator, 8) water bath, 9) flow calibrator, 10) Tenax-Thermal adsorption tube;11) Air sampling pump

Fig. I Experimental model for VOC measurement [18].

III. STUDY WITH EMPHASIZE ON IN-VEHICLE POLLUTION

Outflow of this Volatile Organic Compounds from different materials from in vehicular cabins is one of the major reasons of poor in-vehicular air quality. Introduction to these VOCs have as of late turned into an open concern, causing present moment and long haul sway on human wellbeing. The major pollutants in in-vehicle are Volatile Organic Compounds, for example, Benzene, Toluene, Ethyl-benzene, and Xylene. These may cause intense and constant impacts on long haul and momentary effect separately. In-vehicular air quality can assume an essential job in falling apart the strength of individuals. These air contaminations may incorporate unstable natural mixes (VOCs) including fragrant and aliphatic hydrocarbons. In- Vehicle air contamination are releasing from inside materials utilized in vehicle's construction, motor emanations, entering the vehicle through openings, and encompassing pollutants entering with the ventilated air. The normal convergences of in-vehicle VOCs are regularly higher than those in encompassing air. Intense and endless presentation to VOCs can prompt a scope of wellbeing impacts. In this way it ends up important to break down these dangerous contaminations and uncovering its precise wellspring of generation or emanation.

Study on In-vehicle VOCs in taxi shows that Refuelling augmented the in-vehicle concentrations of this toxic pollutants. BTEX concentrations in observed taxi models were greater for gasoline. Taxi age did not upset BTEX concentration [3]. Study on prediction of emission of VOCs from materials in vehicle cabins shows that C_0 (initial emit able VOC concentration) of all the studied VOCs was increasing with an increase in temperature [1]. Refuelling expanded the in-vehicle contaminations. BTEX concentration in taxi models were higher for VOCs. Taxi age did not influence BTEX concentration [4]. Contingent upon the vehicle type and its element, the convergence of hydrocarbons differed from 12% to 27% of all out VOCs [5].

All VOCs are imperative because of their effect on human wellbeing and the environment. However BTEX are viewed as the most harmful of these species in petro substance industry. The BTEX mixes are imperative group of organo-poisons which are segments of gas and flight energizes and are generally utilized in industrial forms. They are cancer causing and neurotoxic and are delegated earlier as toxins by the Environmental Protection Agency (EPA). Benzene, Toluene, Ethyl-Benzene, and Xylene (BTEX) are recovered amid non-renewable energy source extraction and utilized as solvents in shopper and modern items, as fuel added substance and as middle of the road in the combination of natural mixes for some customer items. Outflow from burning of fuel and diesel are the biggest supporters of BTEX fixation to environmental. Also, the dimension of these BTEX mixes are substantially more in In-vehicular cabins because of less scattering, less territory contrasted with encompassing. VOCs concentration depends on Ventilation Condition. After a particular usage of vehicle, the VOCs emission decreases due to decreasing VOCs residual in the interior trim [6]. BTEX occurs normally in raw petroleum and furthermore can be found in ocean water in the region of flammable gas and oil stores. The other non-anthropogenic wellsprings of BTEX age are volcanoes and backwoods fires.

The extremely essential anthropogenic BTEX mixes discharges from outflow from engine vehicles, air ships, and tobacco smoke. The BTEX mixes are additionally made amid the handling of oil based commodities, likewise amid the creation of purchasers merchandise, for example, paints and thinners, finishes, elastic items, inks, adhesives, pharmaceutical items and cosmetics [3]. These compounds falls in the category of most copiously delivered chemicals on the planet. Petroleum station regions had higher concentration of BTEX toxins contrasted with regular urban streets. This implies oil station zones can possibly export high concentration of BTEX toxins when precipitation happen [5].Study shows that depending on the vehicle type and its feature, the concentration of this aromatic hydrocarbons (VOCs) varied from 12% to 27% of total VOCs [5]. TVOC originates from off-gassing of interior materials [5]. The process of refueling and substitution of gasoline including compressed natural gas and liquefied petroleum gas can be considered as the solutions to recover in-vehicular air pollution for taxis [4].

The BTEX contamination from in-vehicular cabins of mass transports is however not so normal, yet consistent introduction from BTEX compounds causes an endless wellbeing impact to human. The materials utilized in transports, materials and things conveyed in by the travelers in the transports, the state of the transports, age of the transports, support of the transports, sort of fuel utilized in the transport motor framework, any spillage present in transports, encompassing condition of the transport going through, on what kind of streets the transport is moving, length of the street secured by the transport, width of the street, surrounding temperature just as in-vehicle temperature, number of vehicle present out, speed of the transport, number of oil siphons (petrol pump) on that street, number of travelers in transport, method of transport (regardless of whether it is in movement or it is on ideal condition), material utilized in transport (seats, floor, window material), whether transport if completely AC or Non-AC, other meteorological parameters, for example, wing speed, wing bearing, dampness, season, the ventilation arrangement of the transport; every one of these parameters assumes an essential job in the outflow of BTEX in-vehicular cabins of transports materials in vehicle cabins is one of the principle purposes behind poor in-vehicle air quality [1].

Study shows that VOCs in 'idling engine' was 1.3-5 times higher than the 'engine off' levels [8]. A car vehicle is a specific environment of human life where levels of volatile organic compounds concentration are much higher than i.e. in buildings, houses, offices [9].

IV. STUDY WITH EMPHASIZE ON VEHICLE INTERIOR GEOMETRY, AGE AND INTER-VEHICLE SPACING ON IN-VEHICLE POLLUTION CONCENTRATION

Changes in vehicle geometry cause change in carcinogens distribution, especially for particular health-hazardous benzene [9]. The geometry affect the ventilation process inside the vehicular cabin and thus results in affecting the dispersion of VOCs. In-vehicular VOCs and $PM_{2.5}$ concentrations revealed that a 19-31% reduction was observed at the larger inter-vehicle spacing [10]. If the inter-vehicle spacing between vehicles during traffic is more than it will allow the dispersion of VOCs and force stop the entering of these VOCs inside the vehicle from surroundings.

The geometry ought to be with the end goal that legitimate ventilation occur and enables outside air to enter the vehicular cabin. Depending on ideal geometry according to computational fluid dynamics modelling of a vehicle, the flow rate of atmospheric fresh air of 9.2 l/s per passenger was found sufficient to reduce the carbon dioxide concentration inside the cabin to a safe value of 1000 ppm [1].

The concentrations of VOCs in older metro carriage was found to be 1-2 times higher than the newer metro carriages, as better paintings were used in those new trains [13].

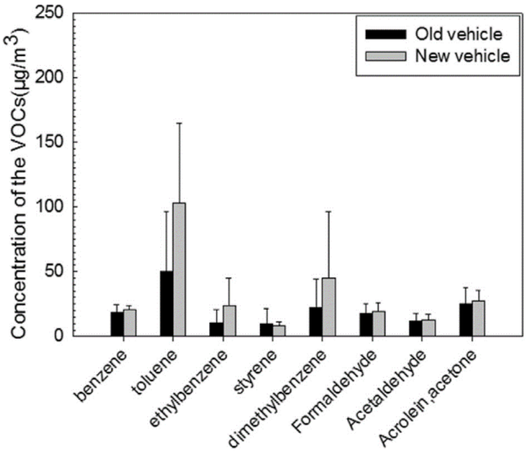


Fig. II Comparison of old and new vehicle for VOCs generation [17].

The above graph shows that the concentration of VOCs is lesser compared to newer vehicle. The new vehicle having newer paints releasing VOCs and this add up to the concentration of VOCs inside the vehicle cabin.

V. STUDY WITH EMPHASIZE ON COMMUTERS EXPOSURES TO VOC

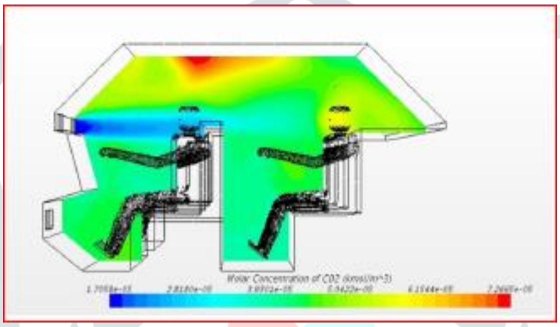


Fig.III Exposure of passengers to VOCs [3].

The above fig. of computational fluid dynamics shows the dispersion of in-vehicular pollution and its impact on passengers seated inside [1]. Study on the BTEX pollutant load characteristics in the urban environment shows that the Benzene pollutants are toxic and can cause human health risk [2].

The level of exposure of commuters depends on the engine type and technology installed in the vehicle. The in-vehicle concentration varied with engine type and age of the vehicle [12]. The paints are having greater impact on the generation of VOCs and thus it also affect the human health on continuous exposure. The car commuters were exposed to higher levels carbon monoxide and VOCs. Pedestrians were exposed to lower carbon monoxide and VOCs concentrations [11]. BTEX compounds causes various diseases such as; sperm abnormalities, reduced fetal growth, cardiovascular diseases, respiratory dysfunctioning, asthma, etc on continuous exposure while travelling in mass transportation [6]. Study founded that the concentration of BTEX inside the vehicle was more compared to ambient as the dispersion level in the outer atmosphere was higher compared to in-vehicle cabin and this was observed by identifying the wind speed [15].

VI. STUDY WITH EMPHASIZE ON EFFECT OF METEOROLOGICAL PARAMETERS ON IN-VEHICLE VOCS

The meteorological parameters play a vital role in diffusion characteristics of VOCs. The parameters such as Wind direction, Wind speed, Humidity, Temperature are of the main importance. Combined effect of temperature and humidity on indoor air pollution share source effect and sink effect. VOCs have combined effect of humidity as sink effect [14].

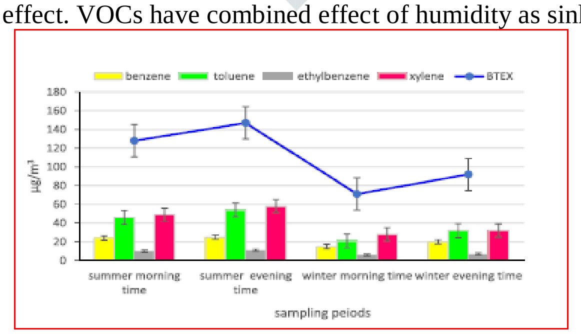


Fig.IV Seasonal variation of VOCs [18].

Above graph shows the seasonal variation in the concentration of VOCs and it was observed that during summer the VOCs concentration was higher compared to winter season.

The concentration of BTEX level was to found comparatively high in- vehicle compared to ambient atmosphere and it was also observed that the VOCs generation was higher during summer unlike winter season [4]. The diurnal variation of BTEX in four seasons was observed and the correlations between BTEX and NO indicated that vehicular exhaust might be the primary source of BTEX [16]. The diffusion process of VOCs is extremely dependent on temperature. If there is rise in temperature and if the latent heat is achieved than the diffusion process takes place and it again depends on the materials or source from which VOCs is off-gassing.

VII. DISCUSSION

The impact of VOCs is maximum inside the compact and closed cabin of a vehicle compared to atmospheric VOCs as there is good possibility of dispersion in outer atmosphere unlike in-vehicular cabins. Diesel fuelled vehicle showed high concentration of VOCs compared to Gasoline, LPG and CNG fuelled. The generation rate of VOCs increases with the increase in temperature and decreases with increase in wind velocity. The age of a vehicle also shows effect on VOCs generation, as vehicle age increases, the capability of vehicle to emit VOCs from internal materials used, paints applied decreases. But if there is any leaks present in the older vehicle than it can enhance the concentration of VOCs inside the vehicle. During the traffic, idling of vehicle increases the VOCs concentration inside the vehicular cabin. The more inter – vehicle spacing, lesser is the concentration of VOC in In-vehicle. AC vehicle shows lesser VOCs concentration compared to Non-AC vehicle as the outer pollution also do enter these vehicle from windows. Proper ventilation helps in decreasing the concentration of VOCs inside the transport.

VIII. CONCLUSION

Review of research papers established the gaps in research. Accordingly, it also revealed below given future perspective of In-Vehicular VOC research;

1. The research on In Vehicular pollution was mostly carried out inside the cars, which cannot give proper view for In-vehicle VOC pollution such as public buses, travelers as a huge part of human population travel through these transport facilities.
2. The research fails to differentiate the generation of VOC in AC and Non-AC vehicle, as most of the research is done on AC coaches of cars.
3. The study revealed that even the less concentration of VOCs in In-Vehicle can pose significant health impact on continuous exposure.
4. The key sources that can be identified for VOCs generation in In-Vehicle include paints, leather material, seat material, use of plastic, things carried with passengers, presence of leaks, vehicle age, outer pollution entering the cabin, fuel type.
5. The meteorological parameters affecting the VOCs generation are; temperature, Wind speed, Humidity, Wind direction.

It is not possible to avoid this toxic In-vehicle pollution due to VOC as it is having significant health impact on humans, but for its reduction some points can be consider;

1. Proper geometry of the vehicular cabin can lead to VOC decrement inside the vehicle.
2. The ventilation of vehicle can keep check on VOC generation rate if designed in a proper way.
3. Regular maintenance of vehicle can avoid the formation of leaks inside the vehicle which can stop pollution entering from that path.
4. The use of LPG and CNG is the other way to reduce the VOC pollution.

There is no proper guidelines and monitoring for VOC measurement inside the vehicle, which can be implemented so as to keep check on this toxic compounds.

REFERENCES

[1] Bolden, A. L., & Kwiatkowski, C. F. (2016). Response to Comment on "New Look at BTEX: Are Ambient Levels a Problem? Environmental Science & Technology, 50(2), 1072-1073. doi:10.1021/acs.est.5b06048

[2] Brodzik, K., Faber, J., Łomankiewicz, D., & Gołda-Kopek, A. (2014). In-vehicle VOCs composition of unconditioned, newly produced cars. Journal of Environmental Sciences, 26(5), 1052-1061. doi:10.1016/s1001-0742(13)60459-3

[3] Chang, T., Sheu, J., Huang, J., Lin, Y., & Chang, C. (2018). Development of a CFD model for simulating vehicle cabin indoor air quality. Transportation Research Part D: Transport and Environment, 62, 433-440. doi:10.1016/j.trd.2018.03.018

[4] Afshari, A., Schuch, F., & Marpu, P. (2018). Estimation of the traffic related anthropogenic heat release using BTEX measurements – A case study in Abu Dhabi. Urban Climate, 24, 311-325. doi:10.1016/j.uclim.2017.02.001

[5] Bakhtiari, R., Hadei, M., Hopke, P. K., Shahsavani, A., Rastkari, N., Kermani, M., Ghaderpoori, A. (2018). Investigation of in-cabin volatile organic compounds (VOCs) in taxis; influence of vehicles age, model, fuel, and refueling. Environmental Pollution, 237, 348-355. doi:10.1016/j.envpol.2018.02.063

[6] Dehghani, M., Fazlzadeh, M., Sorooshian, A., Tabatabaee, H. R., Miri, M., Baghani, A. N., Rashidi, M. (2018). Corrigendum to "Characteristics and health effects of BTEX in a hot spot for urban pollution" [Ecotoxicol. Environ. Saf. 155 (2018) 133–143]. Ecotoxicology and Environmental Safety, 163, 686. doi:10.1016/j.ecoenv.2018.07.095

[7] El-Hashemy, M. A., & Ali, H. M. (2018). Characterization of BTEX group of VOCs and inhalation risks in indoor microenvironments at small enterprises. Science of The Total Environment, 645, 974-983. doi:10.1016/j.scitotenv.2018.07.157

[8] Gong, Y., Wei, Y., Cheng, J., Jiang, T., Chen, L., & Xu, B. (2017). Health risk assessment and personal exposure to Volatile Organic Compounds (VOCs) in metro carriages — A case study in Shanghai, China. Science of The Total Environment, 574, 1432-1438. doi:10.1016/j.scitotenv.2016.08.072

[9] Jiang, Z., Grosselin, B., Daële, V., Mellouki, A., & Mu, Y. (2017). Seasonal and diurnal variations of BTEX compounds in the semi-urban environment of Orleans, France. Science of The Total Environment, 574, 1659-1664. doi:10.1016/j.scitotenv.2016.08.214

[10] Kim, K., Szulejko, J. E., Jo, H., Lee, M., Kim, Y., Kwon, E., Kumar, P. (2016). Measurements of major VOCs released into the closed cabin environment of different automobiles under various engine and ventilation scenarios. Environmental Pollution, 215, 340-346. doi:10.1016/j.envpol.2016.05.033

[11] Liu, A., Hong, N., Zhu, P., & Guan, Y. (2018). Understanding benzene series (BTEX) pollutant load characteristics in the urban environment. Science of The Total Environment, 619-620, 938-945. doi:10.1016/j.scitotenv.2017.11.184

[12] M. Z. (2013). Impact of vehicle interior geometry on chosen volatile carcinogens concentration distribution in vehicle cabin. Proceedings of ECOpole, 7(1), 177-184

[13] Mcnabola, A., Broderick, B., & Gill, L. (2009). The impacts of inter-vehicle spacing on in-vehicle air pollution concentrations in idling urban traffic conditions. Transportation Research Part D: Transport and Environment, 14(8), 567-575. doi:10.1016/j.trd.2009.08.003

[14] Miri, M., Shendi, M. R., Ghaffari, H. R., Aval, H. E., Ahmadi, E., Taban, E.Azari, A. (2016). Investigation of outdoor BTEX: Concentration, variations, sources, spatial distribution, and risk assessment. Chemosphere, 163, 601-609. doi:10.1016/j.chemosphere.2016.07.088

[15] Odekanle, E. L., Fakinle, B. S., Jimoda, L. A., Okedere, O. B., Akeredolu, F. A., & Sonibare, J. A. (2017). In-vehicle and pedestrian exposure to carbon monoxide and volatile organic compounds in a mega city. Urban Climate, 21, 173-182. doi:10.1016/j.uclim.2017.06.004

[16] Som, D., Dutta, C., Chatterjee, A., Mallick, D., Jana, T., & Sen, S. (2007). Studies on commuters exposure to BTEX in passenger cars in Kolkata, India. Science of The Total Environment, 372(2-3), 426-432. doi:10.1016/j.scitotenv.2006.09.025

[17] B., Y., & Y. (2016). Investigation of volatile organic compounds exposure inside vehicle. Atmospheric Polution Research, 2(5), 215-220. doi:10.3897/bdj.4.e7720.

[18] Y. H., M. M., & A. M. (2017). Trends of BTEX in the central urban area of Iran. Atmosphere Pollution Research, 1(10), 1-10.

[19] Yang, T., Zhang, P., Xu, B., & Xiong, J. (2017). Predicting VOC emissions from materials in vehicle cabins: Determination of the key parameters and the influence of environmental factors. International Journal of Heat and Mass Transfer, 110, 671-679. doi:10.1016/j.ijheatmasstransfer.2017.03.049