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Sunil Kumar
Ajay Kalamdhad
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Sustainability in Environmental Engineering and Science

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About the Editors

Dr. Sunil Kumar is a Senior Researcher with more than 20 years of experience in leading, supervising and undertaking research in the broader field of Environmental Engineering and Science with focus on Solid and Hazardous Waste Management. Dr. Kumar is heading Technology Development Centre at CSIR-National Environmental Engineering Research Institute, Nagpur, India. His contributions since inception at CSIR-NEERI in 2000 include 140 refereed journal publications, 04 books and 35 book chapters, 08 Edited volumes and numerous project reports to various governmental and private, local and International academic/research bodies. Dr. Kumar was a Visiting Researcher at University of Calgary, Canada, Hongkong Baptist University Hongkong, United Nations University Germany, etc. He has contributed immensely to the advancement of environmental engineering/ science fields in India in the region and internationally by acting as editor/ editorial member of numerous journals, Expert committee member for revision of Solid Waste Manual in India, organizing workshops/conferences and delivering invited speeches at both Indian and international venues. Dr. Kumar was awarded as Outstanding Scientist in 2011 and 2016 at CSIR-NEERI for his Scientific Excellence in the field of Research & Development in Solid Waste Management. Dr. Kumar was also awarded with the most prestigious award Alexander von Humboldt-Stiftung Jean-Paul-Str.12 D-53173 Bonn, Germany as a Senior Researcher for developing a Global Network and Excellence for more advanced research and technology innovation.

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Dr. Ajay Kalamdhad is currently working as a Professor in Department of Civil Engineering, Indian Institute of Technology (IIT) Guwahati. He obtained his Bachelors, Masters and PhD in Civil and Environmental Engineering from GEC Jabalpur, VNIT Nagpur and IIT Roorkee respectively. Prior to joining IIT Guwahati in 2009, He was an Assistant Professor at VNIT Nagpur and worked in various projects at RRL, Bhopal (Now AMPRI, Bhopal) and NEERI, Nagpur. In addition to his books on solid waste management, rotary drum composting and metal speciation, Dr Kalamdhad has published more than 170 research papers in acclaimed journals and has presented his work in more than 200 national and international conferences/workshops. He is associated with Indian Public Health Engineers, India, International Solid Waste Association Italy and National Solid Waste Association of India; and serves as a reviewer for 50 international journals. He is a recipient of ISTE- GSITS national award for best research by young teachers of engineering colleges for the year 2012 and IEI Young Engineers Award 2011-2012 in Environmental Engineering discipline from Institute of Engineers India.

Design and Simulation of Vertical Handover Algorithm for Intelligent Transport System Using Analytic Hierarchy Process

Kankan Ghosh and Rabi Adhikary

1 Introduction

The concept of vertical handover was proposed with the development of various wireless technologies, with the simultaneous positioning of UMTS, GPRS, and GSM as cellular networks and their network implementations, including WiMAX, Wi-Fi [1]. Mobile station capable of handling several technologies should be able to navigate freely from one network interface to another, enabling it to maintain its network connection and QoS required by higher level applications. The tool vertical handover is an extremely important capability for future wireless communications, where the integrated network will seek to provide a global broadband access for mobile users belonging to multiple technology groups. However, compared to horizontal handovers, signal strength metrics are sometimes inappropriate and often insufficient to properly trigger vertical handovers: as different networks characterized by different systems. The signal strength of two cells cannot be compared by their performance [2]. In a given location, multiple networks (WLAN, WCDMA or 3G, and WiMAX) may be available, and on the contrary, it may happen that the desired network, through which the vehicle is currently communicating, is not available in a particular region. So, the network needs to be fixed immediately to ensure QoS. It arranges continuity and handover of existing sessions. Vertical handoff can be divided into three stages: network discovery, handoff decision, and handoff execution [3]. The purpose of this paper is to define an efficient user-driven vertical handover process that does not require any changes to the network and protocol architecture and can be easily applied to existing Wi-Fi/WiMAX/3G systems. To this purpose,

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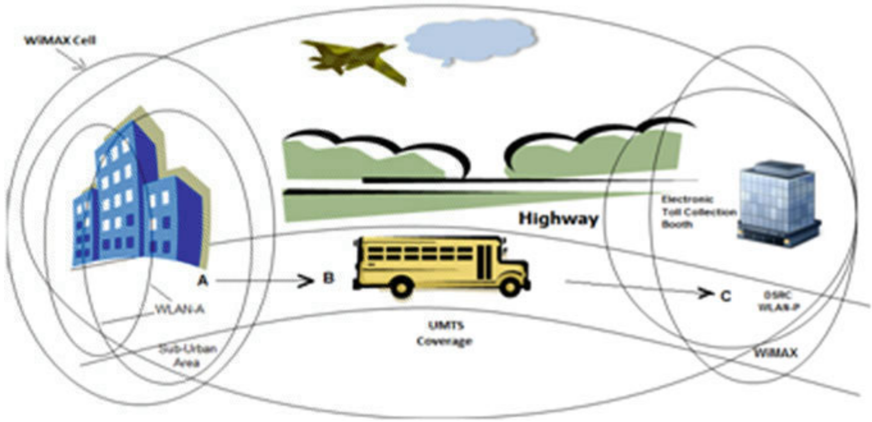

Fig. 1 Pictorial representation of VHO

we first choose the criteria for the performance of the network based on technical and customer requirements. We then propose a novel algorithm which provides automatic handover between the networks and thus increases the performance of the total telecommunication system (Fig. 1).

2 Analytic Hierarchy Process

The analytic hierarchy process (AHP) is a procedure designed to quantify managerial judgments of the relative importance of each of several conflicting criteria used in the decision-making process [4]. The pair-wise comparison on ‘n’ criteria can be summarized in an $(n \times n)$ evaluation matrix ‘A’ in which every element ‘a_{ij}’ (where $i, j = 1, 2, \ldots, n$) is the weight of the criteria, as shown:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & \cdots & a_{2n} \\ \vdots & \cdots & a_{33} & \cdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & \cdots & \cdots & \cdots & a_{nn} \end{bmatrix} \quad \text{where } a_{ij} = 1, \ \text{for } i = j, \ \text{and } a_{ij} = 1/a_{ji} \text{ for } a_{ij} \neq 0 \tag{1}$$

The consistency of judgment needs to be verified through evaluating the consistency ratio (CR). The consistency ratio is:

$$\mathrm{CR} = \mathrm{CI}/\mathrm{RI} \tag{2}$$

where consistency index of comparison matrix CI = $(\lambda_{max} - n)/(n - 1)$, and λ is the Eigen value calculated from the matrix and RI = Random inconsistency. The value of RI is constant, i.e., 0.58 for three alternatives. According to Saaty [5], if the consistency ratio is <10%, then the level of inconsistency is acceptable. It is unique in its ability to deal with intangible attributes and to monitor the consistency with which a decision maker makes his decisions. The process it makes possible to incorporate decision on intangible qualitative criteria alongside tangible quantitative criteria.

3 Design Methodology of Vertical Handover

Analytical hierarchy process or AHP starts by laying out the total hierarchy of the decision-making problem. The hierarchy process is structured from the top (the overall goal of the problem) through the intermediate levels (different criteria on which subsequent levels depend) to the bottom level (the list of alternatives).

Here, in Fig. 2, we discuss three different stages to determine the best network. Each and individual criterion in the lower level of hierarchy is compared with respect to the criteria in the upper level of hierarchy. The criteria in the same level are compared using pair-wise comparison. Figure 3 describes the hierarchy of a decision-making problem.

Once the hierarchy is established, the pair-wise comparison evaluation takes place. All the criteria on the same level of the hierarchy are compared to each of the criterion of the preceding (upper) level. Figure 3 shows that the selection of best

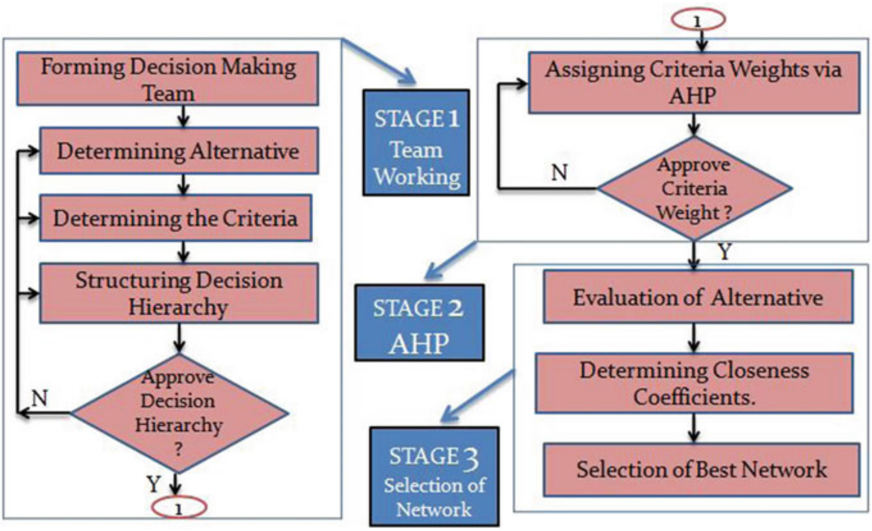

Fig. 2 Flowchart of AHP for vertical handover algorithm

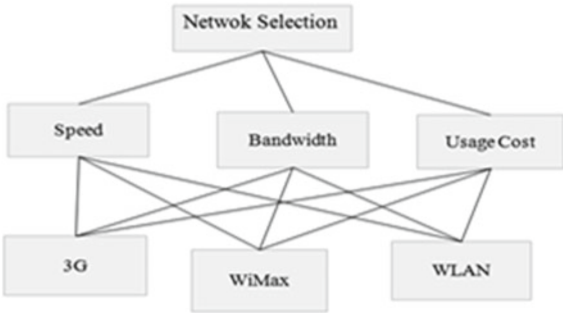

Fig. 3 Hierarchy of criteria for selection of 'best network'

network depends upon the three criteria speed, bandwidth, and data rate. Among the networks 3G, WiMAX, and WLAN, best network is selected. We calculate the closeness coefficient to rank the network. To determine the closeness coefficient, a fuzzy set $\tilde{a}$ in a universe of discourse X is characterized by a membership function $\mu_{\tilde{a}}$, a real number in the interval (0, 1). A triangular fuzzy number $\tilde{a}$ can be defined by a triplet (a_1, a_2, a_3) [6]. The mathematical forms are shown by Eq. (3):

$$\mu_{\tilde{a}} = \begin{cases} 0 & x \le a_1 \\ \frac{x-a_1}{a_2-a_1} & a_1 < x \le a_2 \\ \frac{a_3-x}{a_3-a_2} & a_2 < x \le a_3 \\ 1 & x > a_3 \end{cases} \tag{3}$$

Let $\tilde{a} = (a_1, a_2, a_3)$ and $\tilde{b} = (b_1, b_2, b_3)$ be two triangular fuzzy numbers, then the vertex method is defined to calculate the distance between them, as Eq. (4):

$$d\left(\tilde{a}, \tilde{b}\right) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2\right]} \tag{4}$$

For each criteria at the bottom, set the positive ideal solution and negative ideal solution.

$$d_i^* = \left\{v_1^*, v_2^*, \ldots, v_n^*\right\},\ d_i^- = \left\{v_1^-, v_2^-, \ldots, v_n^-\right\} \tag{5}$$

where d_i^* is the set of positive ideal solutions, v_i^* for all $i = 1, 2, \ldots, n$ is the positive ideal solution to the ith criteria at the bottom. d_i^- is the set of negative ideal solutions, v_i^- for all $i = 1, 2, \ldots, n$ is the negative ideal solution to the ith criteria at the bottom [7].

The closeness coefficient is the distance to the fuzzy positive ideal solution (d_i^*) and the fuzzy negative ideal solution (d_i^-).

Table 1 Computation of d_i^-, d_i^* and CC_i

Networks	d_i^*	d_i^-	$d_i^* + d_i^-$	$CC_i = \frac{d_i^-}{d_i^- + d_i^*}$
WLAN (N1)	1.1428	0.8204	1.9632	0.4178
WiMAX (N2)	1.0859	0.9601	2.046	0.4692
3G (N3)	1.1308	0.8244	1.9552	0.4216

The closeness coefficient (CC_i) for each network is calculated as:

$$CC_i = \frac{d_i^-}{d_i^- + d_i^*} \text{ where } i = 1, 2, \ldots, m. \quad (6)$$

So closeness coefficient is calculated using above formula and is given in Table 1.

The value of closeness coefficient (CC_i) of networks are in the order as follows: N2 > N3 > N1.

So, here the best suitable network is ***WiMAX***.

The ranking order of network is N2 > N3 > N1., i.e., WiMAX > 3G > WLAN.

4 Simulation Results for Voice Application

The model designed in simulink is used to select best network for different speed of vehicle. In this case up to speed of 27 kmph, WLAN network is selected, after 27 kmph, network is handed over from WLAN to 3G, and when the speed of vehicle becomes 60 kmph, the network is handed over to WiMAX. The model is shown in Fig. 4. Performance analysis of three networks on the basis of closeness coefficient and performance index of voice application with respect to vehicle speed. Graphical representation for the choice of networks in case of voice application with respect to closeness coefficient versus speed is shown in Fig. 5.

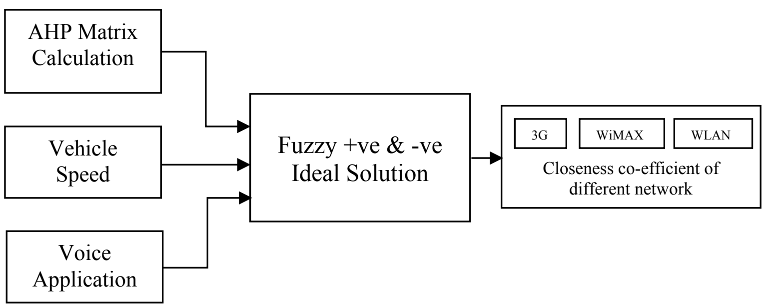

Fig. 4 Block schematic of vertical handover algorithm

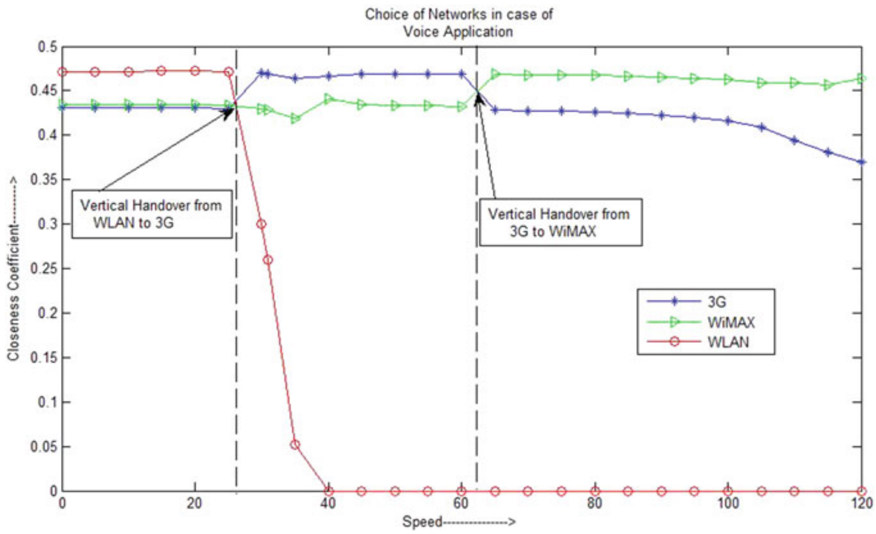

Fig. 5 Simulation graph for handover of networks in case of voice application

From the above graph, we find that weightage of WLAN is maximum at speeds of 0–27 kmph vehicular speed; while that of 3G is the lowest within that range. At speeds of about 27 kmph, the weightage of both 3G and WLAN is almost the same. After 27 kmph, weightage of WLAN decreases and then constant as WLAN cannot support voice communication above vehicular speeds of 27 kmph. Also, beyond 27 kmph, weightage of WiMAX also starts reducing with rise in vehicle speed up to 60 kmph. Handovers take place between WLAN and 3G at about speeds of 28 and 30 kmph, while handover take place between 3G and WiMAX at about speed of 60 and 63 kmph.

5 Conclusion

From the graph, we can say that overall WLAN will be selected for speeds below 27 kmph, whereas 3G is selected between speeds of 27–63 kmph and WiMAX is selected above speeds of 63 kmph. This algorithm, as designed, can be implemented in mobile phones and laptops, so that the appropriate network can be selected whenever the user wants to access the Internet (wireless), when the node is in mobile. However, a limitation of the designed algorithm is that since WiMAX cannot be accessed at vehicle speeds above 150 kmph, this system is limited for speed up to 120 kmph.

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Particulate Matter Emission Assessment and Future Outlook Through Air Dispersion Model for Sustainable Development Planning in an Inland City in Central Maharashtra, India

Sweta Kumari, Adhikari Srikanth, Ashish Patil, Anirban Middey, Aariz Ahmed, and Navneet Kumar

1 Introduction

The concern of air pollution has materialized in developing countries because of its adverse health impact [1]. Increased quantity of vehicles, decreased road capacity, and less investment in public transportation are the major contributor for extreme urban air pollution [2]. Air quality model (AQM) is a critical part of air pollutant prediction and forecasting that are required for urban air quality management. AQM such as AERMOD is well set up in developing countries where the input data are adequate. Air pollution is severely augmenting in India and other developing countries due to growth of population, urbanization, transportation, and industrialization [3]. Research study has confirmed the interim as well as enduring exposure to PM_{10} is allied with amplified motbidity and mortality impacts [4]. Various actions have been initiated previously to deal with air pollution, i.e., comprehensive inspection of pollutin industries, process development, enhanced energy efficiency, vehicle emission control technology, fuel quality improvement, and enforcement of vehicular exhaust norms. Despite of all this actions, PM_{10} has shown rising trend for megacities like Delhi, Mumbai, Kolkata, and Chennai [5]. The possible reason for PM_{10} might be due to inadequate information on sources and its contribution [6].

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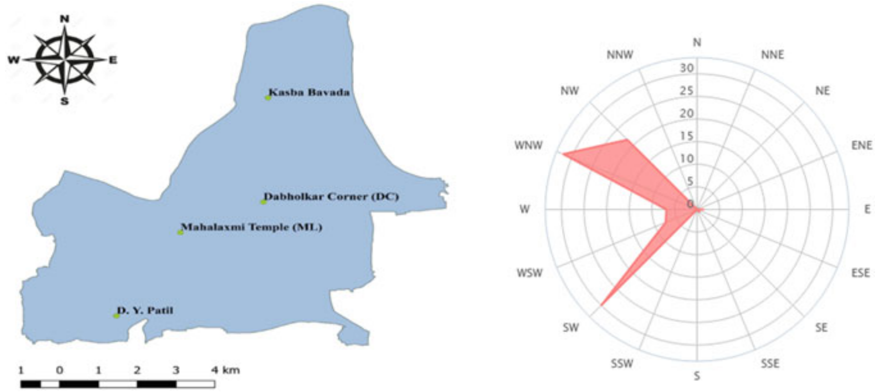

Fig. 1 Study area Kolhapur and wind rose of study area

1.1 Study Area

Kolhapur city is situated at 228 km south to the Pune city. The hottest month is April with average temperature of 29 °C (Max. temperature 35 °C and Min. temperature 24 °C). The coldest month is pace with increasing population in this city. Wind direction distribution (%) in May at Kolhapur (*Source: Windfinder.com*) is shown in the following figure. The study area map and wind rose diagram of the study are has been depicted in Fig. 1.

2 Methodology

2.1 Emission Inventory

Gross emission inventory of different sources of air pollution has been prepared for 10–15 km radial distance from center of Kolhapur city (120 km). The base year 2018 is taken for most of the source data collection. This emission inventory is used to estimate/extrapolate total emissions for the whole of the city for next 5 years. The source-wise emissions are estimated based on activity data and source-wise emission factor for particulate matter (PM_{10} and $PM_{2.5}$). These emission factors are obtained from published documents of CPCB, ARAI, and AP-42 USEPA.

Emission inventory has been prepared in terms particulate matter (PM_{10}, $PM_{2.5}$). Source categories and types of sources of air pollution in Kolhapur are presented in Table 1.

Table 1 Source categories and types of sources of air pollution

Source category	Types of sources
Area sources	• Domestic cooking • Bakeries • Crematoria • Hotels and restaurants • Open eat outs • Open burning (refuse/biomass/tire, etc., burning) • Paved and unpaved roads • Construction/demolition/alteration activities for buildings • Roads, flyovers • Waste incinerators • DG sets
Point sources	• Large-scale industries foundry, distilleries, textile, sugar, etc. • Medium-scale industries • Small-scale industries • five industrial areas
Line sources	• 2 wheelers (Scooters, motorcycles, mopeds) • 4 wheelers (Gasoline, diesel,) • Light commercial vehicles (LCVs) • Trucks (Trucks, min-trucks, multi-axle trucks) • Buses (Diesel)

2.2 *Dispersion Modelling*

In the present study, an air dispersion modelling using AERMOD has been performed to see the present scenario of particulate matter as well as a prediction for upcoming five years scenario. The dominant emissions of particulate matter, (both PM_{10} and $PM_{2.5}$), are ascribed to growing industrial activity in foundry, vehicular traffic, stone crushing units, and construction projects as well as commercial and infrastructure development including road construction, etc.

2.3 *Ambient Air Quality Monitoring at Receptor*

The air quality monitoring was performed for PM_{10} and $PM_{2.5}$ in order to validate the dispersion modeling with ground truthing. Total of four sites have been selected based on the different categories, i.e., kerb site, commercial site, residential site, and control site. Air quality monitoring was conducted for 10 days 24 h basis with Quartz and PTFE filter paper.

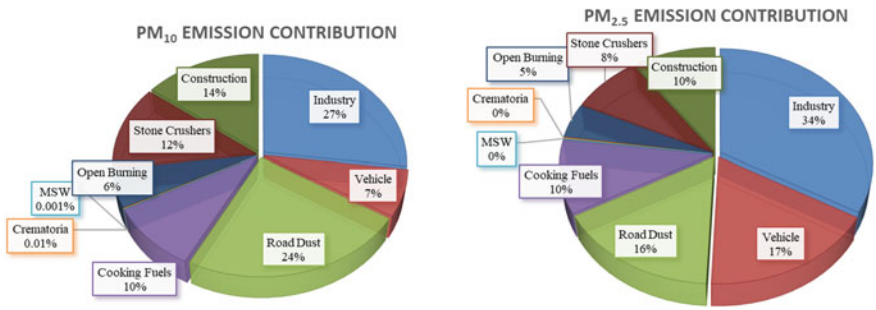

Fig. 2 Source contribution to the PM_{10} and $PM_{2.5}$ emissions

3 Result

3.1 Emission Inventory

From the source emission inventory of the city, it has been found that the major sources of PM_{10} are industry (27%), road dust (24%), construction (14%), stone crusher (12%), cooking fuels (10%), vehicle (7%), open burning (6%), crematoria (0.001%), and municipal solid waste (0.01%) in decreasing order. While the main contributing sources for $PM_{2.5}$ were found as industry (34%), vehicle (17%), road dust (16%), construction (10%), cooking fuels (10%), stone crusher (8%), open burning (5%) in decreasing order. The results obtained in this study reveal that the major source for both pollutants varies slightly in their input. Emission sources and their contribution to particulate matter pollution are shown in Fig. 2.

3.2 Disperssion Modelling

The dispersion of PM_{10} has shown the highest level concentration of 97.22 μg/m^3 which has found in core area of city. As the pollutant dispersed outwards the city, the concentration goes down with minimum concentration value of 0.97 μg/m^3. The PM_{10} disperssion has been depicted in Fig. 3, while the dispersion of $PM_{2.5}$ has shown the highest level concentration of 62.0 μg/m^3 which has found in core area of city. As the pollutant dispersed outwards the city the concentration goes down with minimum concentration value of 0.5 μg/m^3. The $PM_{2.5}$ disperssion has been depicted in Fig. 4.

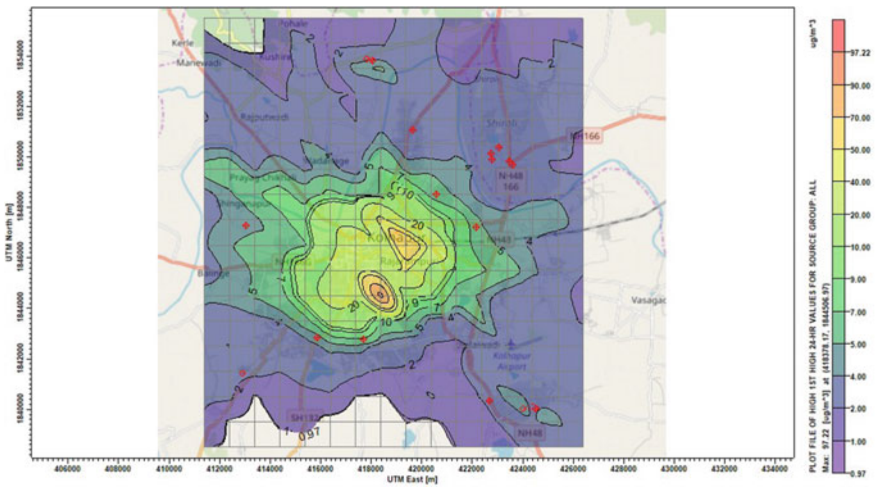

Fig. 3 Illustration of PM_{10} disperssion in Kolhapur region through dispersion modelling

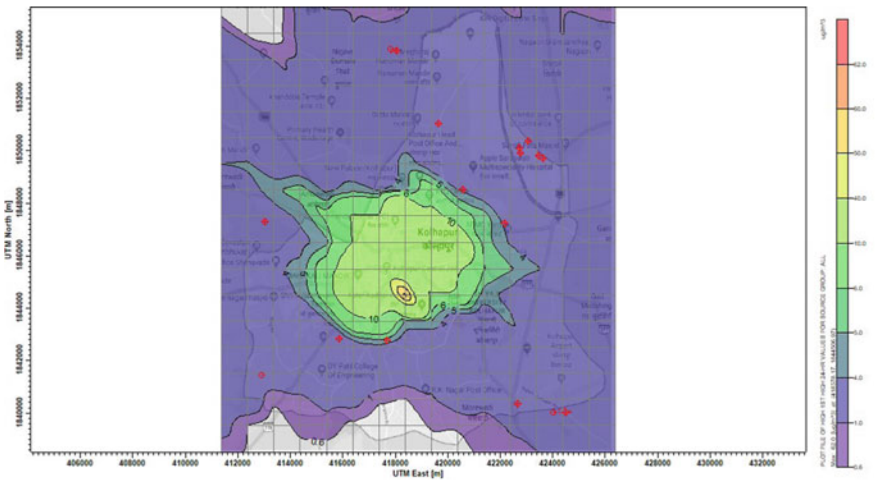

Fig. 4 Illustration of $PM_{2.5}$ disperssion in Kolhapur region through dispersion modelling

3.3 Monitoring

The monitoring of air quality has shown the highest concentration of PM_{10} at site I (kerb site) of 111 $\mu g/m^3$ followed by site II (commercial site) with concentration of 92 $\mu g/m^3$. Site III (residential) and site IV (control) have shown PM_{10} concentration of 78 $\mu g/m^3$ and 53 $\mu g/m^3$, respectively. The $PM_{2.5}$ showed maximum value of

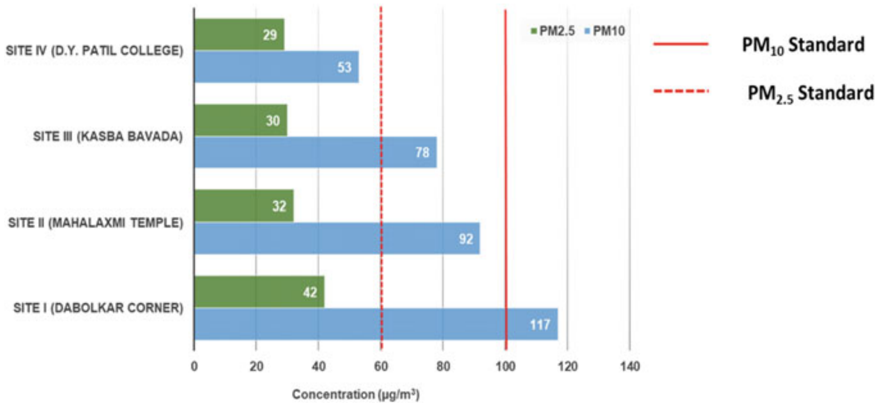

Fig. 5 PM_{10} and $PM_{2.5}$ ground-level concentration at selected monitoring sites

42 $\mu g/m^3$ at site I(kerb site) followed by site II (commercial site) with value of 32 $\mu g/m^3$. The site III (residential) and site IV (control) show the $PM_{2.5}$ value of 30 $\mu g/m^3$ and 29 $\mu g/m^3$, respectively. The bar diagram representing the value of PM_{10} $PM_{2.5}$ has been depicted in Fig. 5.

4 Discussion

4.1 Point Source Mitigation Action Plan

A range of air pollution control system needs to adopted to mitigate the emission from point source. The control technologies recommended for the industries within city impact zone, include fuel substitution, changes in production process, and pollution abatement through flue gas treatment, etc., to reduce the ambient concentrations of pollutants.

4.2 Area Sources

Busy urban areas with commercial activities, which give rise to pollution from area sources, surround city. Unpaved roads re-suspension dust is due to vehicle movements, domestic/residential burning, crematoria's, solid waste burning, etc., which form the major contributors of area sources. Paving the unpaved roads can help in reducing the road dust emission. Construction and demolition are another sources of particulate matter which can be reduced by stringent enforcement of C&D rule, 2016. Few cooking fuels are also responsible for increase in particulate matter, i.e., firewood, crop residue, cow dung cake, coal, and kerosene. The burning of such fuels in domestic as well as in restaurants should be monitored and reduced by distributing cleaner fuel. The open burning of garbage and litters should be strictly prohibited. Therefore, LPG and biogas facility provision is to be increased from current 65% scenario to 70% by 2019, to 75% by 2020, and to 80% by 2021 to achieve the targets proposed in strategic plan. Furthermore, the slum area, open burning from dumpsite and crematoria has also contributed in air pollution. There are sentiments involved in the activities that are carried out in crematorium. Still all crematoria should be provided with efficient pyres and chimneys with bag filters for release of emissions through stacks at appropriate height. Further, a study involving usage of NG burners in a closed furnace like electrical crematoria may be explored as substitute to existing practices. This will require participation of social organizations for increasing the awareness about need to change from the traditional methods. Concept like Green Crematoria should be explored. It has been observed that the unaccounted or mismanaged waste from SWM system, often are reported into road side/slum areas open burning cases. As city is receiving 60MT of solid waste per day, proper collection and disposal practices should be adopted on daily basis so that opening burning cases are not reported. Fast track steps for scientific SW management. Refuse of all types are burning from certain localities slum areas where auxiliary and small scale industries are located should restricted. This practice needs to be stopped by planning of dumping till sanitary landfills are made.

4.3 Line Sources

Since city has large network of roads and busy urban areas, with roads running all around its periphery, a synchronized auto traffic signal system needs to be provided at all the intersection around the monument, for better and smooth flow of vehicles with minimum halt period.

The pollution from autoexhaust is the most important causative factor in busy congested roads. Therefore, the traffic on the roads around the city should be minimal with complete ban on heavy traffic. Commercial vehicles, particularly autos, school/other buses, taxis, and buses were found quite old. Adoption of regular inspection and maintenance program for these vehicles are suggested in order to meet emission norms. Ban of old commercial vehicles may be promulgated.

Implementation of the expert committee recommendations on Auto Fuel policy (August 2002) with respect to different categories of vehicles should be ensured.

The continued growth in the future demographic profile of the automobile is inevitable. Thus, it becomes imperative to control the autoemissions at source. The best strategy is proper maintenance and tuning of the carburetor of the gasoline-powered vehicles which can ensure low CO and HC levels. PUC system needs to be upgraded with latest state-of-the-art technology.

5 Conclusion

Emission inventory of the city shows maximum source contribution of industry, road dust, stone crusher, cooking fuels, vehicles, open burning, and crematoria.

The projected ground-level concentration (GLC) using the dispersion model reveals the appalling future scenario if the present situation is not tackled with proper mitigation measures and controls. Dispersion of PM_{10} and $PM_{2.5}$ shows hotspot regions for particular meteorological condition. Site-specific mitigation measure is also possible from this study.

Ground truthing with ambient air quality measurement at receptor locations shows similarity with forecasted GLC from air dispersion model (ADM).

This study suggests different action plan management deal with air pollution with bottom-up approach. This study will be helpful in air quality management, health management and urban planning of Kolhapur city.

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Assessment on Prevention of Groundwater Contamination

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1 Introduction

Groundwater is the water present below the surface of the Earth in soil pore spaces. It contains soil humidity, frozen soil, immovable water in very low permeability bedrock. Groundwater may provide lubrication which helps in the movement of faults. Groundwater is recharged from the surface via water cycle and can be discharged from the surface of the Earth in the form of springs. Groundwater is used for agricultural, municipal, etc., by people across the globe. Hydrogeology defines the study of the distribution and movement of groundwater.

Groundwater pollution (also called groundwater contamination) occurs when pollutants are released to the ground and seeps deep into groundwater. This occurs naturally for the presence of a minor and unwanted constituent, contaminant, or impurity in the groundwater. The causes of groundwater pollution include

- Naturally-occurring
- On-site sanitation systems
- Sewage and sewage sludge
- Fertilizers and pesticides
- Commercial and industrial leaks.

The different methods that can be used to prevent groundwater contamination are:

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- Groundwater quality monitoring: Groundwater quality monitoring programs play a major role in preventing groundwater contamination. It have been implemented regularly in many countries around the world. Groundwater quality must be regularly monitored across the aquifer to determine the quality of the water. Effective groundwater monitoring should be carried out by a specific objective such as a specific contaminant of concern. It can be achieved by checking the contaminant levels and comparing to the World Health Organization (WHO) guidelines for drinking water quality.
- Locating on-site sanitation systems: The health effects of toxic chemicals arise after a long time exposure are higher as compared to health from chemicals. Thus, the quality of the groundwater at source plays an important component in controlling whether pathogens may be present in the final drinking water. Some of the conditions for safe siting are:
  - Aquifer type
  - Groundwater flow direction
  - Impermeable layers
  - Slope and surface drainage
- Educating the farmers about the proper use of pesticides and fertilizers
- Limited use of chemicals by industries.

The options for remediation of contaminated groundwater can be grouped by:

- Removal of the pollutants to prevent them from further contamination of groundwater.
- Removing the pollutants from the aquifer itself.
- Remediating the aquifer by detoxifying the contaminants at the location of the aquifer (in situ).
- Treating the groundwater at the point of its usage
- Abandoning the use of this aquifer's groundwater and finding an alternative source of water.