JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

STUDY OF AMBIENT AIR QUALITY INDEX AND HUMAN HEALTH IMPACT AT SATNA CITY

Priti Singh Parihar[1] & Shivesh Pratap Singh[2]

1. Research Scholar, A.P.S. University, Rewa, M.P.486003

2. Professor, Govt. Autonomous PG College, Satna M.P. 485001

ABSTRACT

This study presents data on the concentration of ambient air pollutants at different sampling area of Satna city. The ambient air quality study was carried out at four different locations with respect to PM_{10}, $PM_{2.5}$, SO_2, NO_2, NH_3 and O_3, and monthly air sampling was carried out for a period 24 hrs at each of the site. Human health is closely related to his environment. The primary objective of this review is to analyze the causes and sources of air pollution and its negative impact on human health. Air pollution is an immense problem due to its detrimental health effects on human populations. Pollutants concentration was used to calculate the air quality index which ranged between 90 to138.51 thus categorizing the sites from satisfactory to moderate category on a five level air quality index with potential health hazards.

These results indicated that the main sources of air pollution at Satna city are the traffic activity & road construction. The mean levels of PM_{10} at most selected sites were higher than the recommended air quality guidelines. The harmful effects of air pollution on human health and well-being were also presented in this research paper.

Keywords: Air Pollution, Pollutant, AQI, health.

1.0 Introduction

Air quality has deteriorated due to both human activities and natural phenomena such as windblown dust particles. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty.

Clean air is what all living humans and animals needs for good health and well-being. However, due to unstoppable urban development, the air is continuously polluted. Urban ambient air is more polluted than overall atmosphere, due to high density of human population and their activities in urban areas; it produces air pollutants with a higher rate as compared to less-developed areas and natural environment (Ling et al. 2012).

Air pollution can be classified according to its source, origin, chemical composition, size, and releases from indoor or outdoor (Bernstein et al. 2004). According to its source, air pollution can be divided into two main categories: natural or man-made pollution and stationary or mobile pollution. Natural pollutants are emitted directly from natural sources. Natural pollutants comprise forest fires, volcanic eruption, dust storm, pollen grain, radon gas which is a result of radioactive decay of the earth's crust, microorganisms, natural radioactivity, fog, mist, and ozone (Appannagari 2017). The adverse health effects, such as respiratory morbidity, cardiovascular diseases and mortality, have created a public awareness to the urban air pollution. Evaluations and assessments on health have become more important since they serve as a basis to carry out areformulation or review on the current air quality standards (Colls & Micallef, 1997)

Quality of air is one of the basic indicators of the overall status of environment. Air pollution is a local as well as regional issue in major cities of world. Many developing and developed countries have seen progressive decline in air quality as a consequence of rapid development over the last few decades. In the cities of developing countries, the environmental problems are much greater, because of overwhelming scale and speed of urbanization. Urban areas are one of the major sources of air pollution and have characteristic patterns of pollutant emissions with adverse effect on biodiversity and seriously affect people with respiratory problems and cardiovascular diseases (Miller 1997; Mills et al., 2005).

There are two types of environment: natural and man-made. Natural environment composes of everything that affects an organism during the course of its lifetime, such as air, water, soil, radiation, land, forest, wildlife, flora and fauna etc. From a human perspective, environmental issues involve concerns regarding science, nature, health, employment, profits, politics, ethics and economics (Enger & Smith, 2003).

Sulphur dioxide, carbon monoxide, particulates, volatile hydrocarbons, photochemical oxidants, and lead, to be the greatest threats to human health (Cunnningham et al, 2005). No doubt, these pollutants have the capabilities to threat the human health and environment, and could cause significant damages to properties. As stated by numerous scholars, particle pollution and ground level ozone are at the pinnacle among six other pollutants as the most threatening factors to the human health. The epidemiology and laboratory studies also demonstrated that ambient air pollutants (for example, PM, O3, SO2 and NO2) contributed to various respiratory problems including bronchitis, emphysema and asthma (Ling et al, 2012). Urban air pollution due to vehicular emission is responsible for higher levels of air pollutants including trace metals and their adverse effects on human and environmental health (Aggarwal et al., 2003; Baldasano et al., 2003; Kaushik et al., 2006; Barman et al., 2010).

Environmental pollution has emerged as a significant global concern in recent times, particularly in one of our most invaluable natural assets: the air we breathe. The escalation of air pollution has become a daily reality, and its impact on human health is very prominent. US-based studies showed that exposure to fine particulate matter

(PM) can curtail lifespans (Pope et al., 1995), and air pollution has been correlated with adverse respiratory effects and even cardiac-related fatalities (Brunekreef, 2002).

More than 2 million premature deaths each year can be attributed to the effects of urban outdoor air pollution and indoor air pollution (caused by the burning of solid fuels). More than half of this disease burden is borne by the populations of developing countries (WHO, 2006). Heart attacks, respiratory diseases, and lung cancer are all significantly higher in people who breathe dirty air compared to matching groups in cleaner environments (Cunningham, et al 2005). Hundreds of deaths have been directly related to poor air quality in cities.

Air pollution can be also defined as a destructive effect of any source which contributes to the pollution of the atmosphere and/or deterioration of the environment (Ghorani-Azam et al. 2016).

It is well known that air pollution is one of the most important reasons for serious human health effects including cardiovascular and respiratory illnesses. Currently, numerous evidences proved the noxious influences for air pollution on productivity, behavior, and well-being of those exposed. It was also detected that air pollutants adversely affect the workers and worked hours (Hanna 2015; Zivin and Neidell 2012).

Tiny particles that can be inhaled and cause respiratory problems. Particulate matters smaller than 2.5 mm are considered as most noxious pollutant as they can be inhaled and enters the lung and damages the respiratory tissues. In Urban and indoor air, cigarette smoke and asbestos fibers are categorized among most dangerous particle because of their carcinogenic effect that leads to cancer (Cunningham et al, 2005).

The negative correlation of O_3 with air pollutants can be understood in the light of titration processes taking place between NO and O_3, and as a result, NO_2 is formed during this process which is a major contributor to the formation of O_3 and O in the atmosphere (Latif et al. 2012).

Effects of air pollutants on living organism will not only be limited to the human and animal health but also include the whole environment. Different geographical conditions, global climate changes, and the environmental variations affect the human health and the environment including the animal life. Air pollution is a significant determinant of health. There is a direct relationship between air pollution and related health risks, as it interacts with multiple elements of both the social and physical environment, leading to an unequal burden of disease among economically disadvantaged populations. (Aarnio, 2005). Poor air class adversely affects human health and the environment (Sarah, et al., 2019). Air pollution has emerged as a significant issue in recent decades, exerting a profound toxicological effect on both human health and the environment. The long-term consequences of air pollution are well-documented, contributing to the development of various diseases, including respiratory infections, inflammatory conditions, cardiovascular disorders, and cancer. Consequently, air pollution is linked to millions of deaths worldwide annually (Shaharukh, 2020).

1.1 Study Area

Satna is a city located in the northeastern part of Madhya Pradesh, India. It is a significant district for mineral production, containing deposits of limestone, ocher, bauxite, and various other minerals. Satna has developed into a significant industrial center, hosting a range of industries including cement production, thermal power generation, and chemical manufacturing facilities. Cement industry is flourishing in Satna district due to rapid population growth, the change in living style, and the availability of raw material in the region. Unless restricted regulations are enforced by pollution control board and localities to ensure compliance with national and international standards upon this industry, the increase of cement factories and their associated quarries in the region may deteriorate air quality and thus threaten the fragile ecosystems in the region. The increasing number of vehicles on the streets of Satna has exacerbated the city's air quality issues. Poorly maintained vehicles, outdated emission control standards, and insufficient traffic management contribute significantly to the rise in harmful exhaust emissions, particularly in urban regions.

2.0 Materials and Method:

From four selected area, concentration of air pollutants viz. PM_{10}, $PM_{2.5}$, NO_2, SO_2, NH_3, and O_3 levels were collected from different area of at Satna city for 24 hours at Every 30 days and after monitoring it procedure in to lab and analysis for the concentration level.

All the parameters will be analyzed as per IS: 5182/CPCB guidelines. Monthly sampling will be done at all the selected stations. Respirable Dust Sampler (RDS) Sampler will be used for particulate (PM_{10}) & gaseous sampling and Fine Particulate Sampler for ($PM_{2.5}$). All parameter were compared with NAAQS Standards.

Ambient air pollution study will carried out in several locations of Satna City. Four expected air quality monitoring stations representing different area.

Table No.:- 2.1 Different sampling location of Satna City.

Sr. No.	Location	Site	Details
1.	S-1	Residential	Lat. 24.565300 Long. 80.875366
2.	S-2	Industrial	Lat. 25.102872 Long. 80.529015
3.	S-3	Commercial	Lat. 24.576095 Long. 80.822969
4.	S-4	Silence	Lat. 24.580925 Long. 80.826209

Table 2.2 Testing methods for different parameters of ambient air.

Sr. No	Parameters	Method	Reference
1.	**PM_{10}**	Gravimetric	IS:5182 (Part-23)
2.	**$PM_{2.5}$**	Gravimetric	IS:5182 (Part-24)
3.	**SO_2**	Improved West and Gaeke	IS:5182 (Part-2)

4.	**NO_2**	Modified Jacobs-Hochheiser	IS:5182 (Part-24)
5.	**NH_3**	Indophenol	CPCB Vol. I (NAAQM/36/2012-13)
6.	**O_3**	UV Photometric	CPCB Vol. I (NAAQM/36/2012-13)

3.0 Result& Discussion

Table 2.1 represents the characterization of four selected monitoring sites and table 2.2 represents testing methods for different Parameters. The annual ambient air quality status in the statistics form is shown in Table 3.3. The air quality index (AQI) and its rating scale at four monitoring sites have been shown in Table 3.3.

Table:3.1 Weather result of different parameter year-2022

Month	Max. Temperature °C	Min. Temperature °C	Relative Humidity Morning %	Relative Humidity Evening %	Rainfall (mm)	Wind Speed (km/h)
January	21.5	10.2	86	60	51.4	1.2
February	27.5	12.0	70	35	5.3	1.5
March	35.6	18.5	53	23	0.0	2.0
April	42.4	24.3	27	11	0.0	2.0
May	41.6	26.4	42	23	0.0	2.9
June	39.4	26.5	51	43	0.0	3.4
July	34.7	24.6	78	68	274.4	3.6
August	31.5	23.9	88	76	401.4	3.0
September	32.2	25.0	86	75	157.9	3.0
October	31.8	20.5	79	59	119.7	1.1
November	29.4	13.9	73	48	0.0	1.0
December	26.6	10.6	77	47	0.0	1.0

(Source:-IMD, Satna)

3.1 Temperature

The ambient temperature affects the air pollution. It also influences the rate of chemical reactions in the atmosphere. The minimum temperature was observed 10.2 ^{0}C in January 2022 and maximum 42.4 ^{0}C was observed in April, 2022.

3.2 Relative Humidity

Moisture in the atmosphere changes the nature and characteristics of the pollutants. At night the ground losses heat by radiation and the air which is in contact with ground becomes cooler. The minimum humidity was observed 11% April, 2022 in evening and maximum 88 % August 2022 in morning.

3.3 Wind speed & Wind direction

Velocity and direction of wind have a significant role in the dispersion of air borne materials and therefore determines the air quality of the area. Monthly wind directions and wind speeds were observed for a year. Minimum wind speed was observed 1.0 Km/h in November & December 2022 and maximum 3.6 Km/ h was observed in July 2022. Most of the time wind direction was observed NW.

Table No. 3.2 Ambient air quality parameters at different sampling area year, 2022

S. Code	PM_{10}	$PM_{2.5}$	SO_2	NO_2	NH_3	O_3
S1	95.42±31.15	35.58±11.29	4.81±1.83	11.03±2.64	8.29±3.15	12.31±3.61
S2	114.75±33.77	42.58±13.53	8.48±2.45	17.51±5.26	15.13±4.16	10.4±3.02
S3	118.67±38.54	50.67±18.38	7.59±2.72	15.6±4.95	12.19±2.67	11.82±3.52
S4	83.5±24.51	32.17±10.13	4.62±1.62	10.95±2.75	7.01±2.55	12.22±3.18

3.4 PM_{10} :-Annual average PM_{10} ranged from 83.50-118.67 µg/m^3. Minimum annual average PM_{10} was observed 83.50 µg/m^3 at S4 because this station is situated in Silence area followed by 95 µg/m^3 at S1 respectively; this station is situated East direction (Residential Area). Highest average PM_{10} was observed 118.67 µg/m^3 at S3 because this station is situated in Commercial area followed 115 µg/m^{3}at S2 respectively it is industrial area. The annual average values at S2 and S3 observed for PM_{10} concentration was higher than the permissible limit (100 µg/m^3). Similar values were found by Chaurasia et al., 2020.

3.5 $PM_{2.5}$:-Annual average $PM_{2.5}$ ranged from 32.17-50.67 µg/m^3. Minimum annual average $PM_{2.5}$ was observed 32.17 µg/m^3 at S4 because this station is situated in Silence area followed by 35.58 µg/m^3 at S1 respectively; this station is situated Residential Area. Highest average $PM_{2.5}$ was observed 50.67 µg/m^3 at S3 because this station is situated in Commercial area followed 42.58 µg/m^3 at S2 respectively it is industrial area. The annual average values at all sampling station for year 2022 observed for $PM_{2.5}$ concentration was within the permissible limit (60 µg/m^3).

3.6 Nitrogen Dioxide (NO_2):- Annual average SO_2 ranged from 4.27-9.09 µg/m^3. Minimum annual average NO_2 was observed 10.95 µg/m^3 at S1 because this station is situated in Residential area followed by 11.03 µg/m^3 at S4 respectively; this station is situated Industrial Area. Highest average NO_2 was observed 17.51 µg/m^3 at S2 because this station is situated in Industrial area followed 15.60 µg/m^3 at S3 respectively it is Commercial area. The higher SO_2 concentrations at S2 & S3 are due to industrial, transportation, traffic and road construction activities. The annual average values at all sampling station observed for NO_2 concentration was within the permissible limit (60 µg/m^3).

3.7 Ammonia (NH_3):- Annual average NO_2 ranged from 7.01-15.13 µg/m^3. Minimum annual average NH_3 was observed 7.01 µg/m^3 at S4 because this station is situated in Silence area followed by 8.29 µg/m^3 at S1 respectively; this station is situated Residential Area. Highest average NH_3 was observed 15.13 µg/m^3 at S2 because this station is situated in Industrial area followed 12.19 µg/m^3 at S3 respectively it is Commercial area. The higher NH_3 concentrations at S2 & S3 are due to industrial, transportation, traffic and road construction activities. The annual average values at all sampling station observed for NH_3 concentration was within the permissible limit (400 µg/m^3).

3.8 Ozone (O_3):-Annual average O_3 ranged from 10.40-12.31 µg/m^3. Minimum annual average O_3 was observed 10.40 µg/m^3 at S2 because this station is situated in Industrial area followed by 11.82 µg/m^3 at S3 respectively; this station is situated Commercial Area. Highest average O_3 was observed 12.31 µg/m^3 at S1 because this station is situated in Residential area followed 12.22 µg/m^{3}at S4 respectively it is Silence area. The annual average values at al sampling station observed for O_3 Concentration was within the permissible limit (100 µg/m^3).

Table:-3.3 Status of Seasonal Air Quality Index Selected Station, year 2022.

Name of Location	Season		
	Winter	**Pre-monsoon**	**Post-monsoon**
Residential Area (S1)	118.6	106.94	97.00
Industrial Area (S2)	128.06	125.86	122.78
Commercial Area (S3)	138.51	130.70	126.08
Silence Area (S4)	108.48	90.00	101.66

3.9 AQI:-The AQI result of the study area shown in Table 4.3 and Fig.3.1 to 3.4. It has been observed that more affected during winter season compare to other season, the air quality status was found Moderate category in all season at all sampling area except the residential area was found satisfactory category in Post-monsoon and silence area was found satisfactory category in Pre-monsoon in year 2022. This is because of the road construction work, vehicular movement and industrial activities.

Fig. 3.1 Seasonal AQI Variation of Residential area , Satna, Year 2022

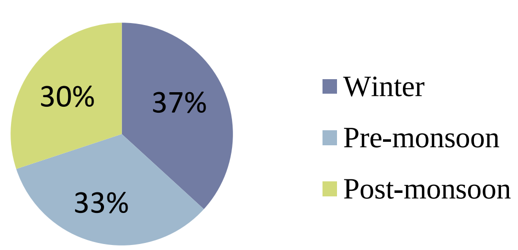


Fig. 3.2 Seasonal AQI Variation of Industrial area , Satna, Year 2022

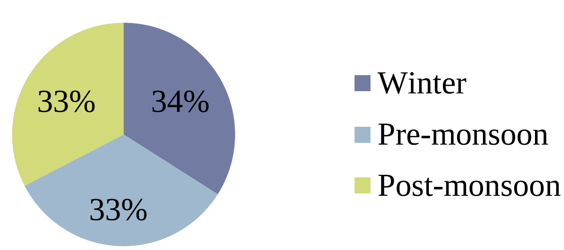


Fig. 3.3 Seasonal AQI Variation of commercial area , Satna, Year 2022

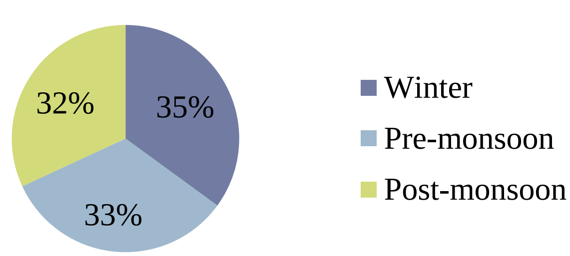
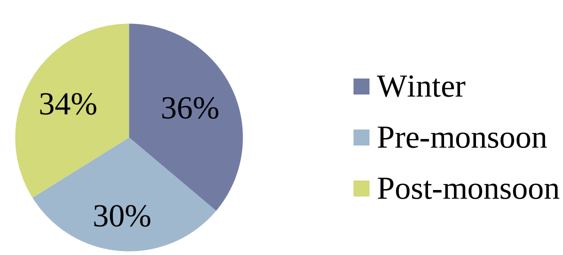


Fig. 3.4 Seasonal AQI Variation of Silnce area , Satna, Year 2022



The present study has attempted to assess air pollution, the relationship between environmental parameters and pollutants in a closed basin as well as the possible source areas by measuring and analyzing the major air pollutant concentration. The pollutant highest concentration was found of ambient air at commercial area followed by industrial area in winter season. Air pollution adversely affects human health. The AQI value was found mostly in moderately category at all sampling area due to higher concentration of pollutants as a resultant of developmental and transportation activities in the study area. The high levels of pollutant especially in winter season are of major health concern because of their synergistic action. The data from selected station from Satna city reveals a significant increase at commercial area with acute respiratory diseases, cardiovascular disease and other related disease when the level of air pollutants was high.

BIBLIOGRAPHY

1. Aarnio P. (2005). The concentrations and composition of and exposure to fine particles ($PM_{2.5}$) in the Helsinki subway system. Atmospheric Environment, 39(28):5059–5066.
2. Aggarwal, M., Singh, B., Rajput, M., Marshall, F. and Bell, J.N.B. (2003). Effect of air pollution on peri-urban agriculture: A case study. Environ. Poll. 126(3): 323-329.
3. Appannagari RR (2017) Environmental pollution causes and consequences: a study 3
4. Baldasano, J.M., Valera, E. and Jimenez, P. (2003). Air quality data from large cities. The Sc. Tot. Environ. 307: 141-165.
5. Barman, S.C., Singh, R., Negi, M.P.S. and Bharagava, S.K. (2010). Assessment of urban air pollution and its probable health impacts. J. Environ. Biol. 31 (6): 913-920.
6. Bernstein JA, Alexis N, Barnes C, Bernstein IL, Nel A, Peden D, DiazSanchez D, Tarlo SM, Williams PB, Bernstein JA (2004) Health effects of air pollution. J Allergy Clin Immunol 114:1116–1123.
7. Brunekreef, B.& Holgate, S.T. (2002) Air pollution and health. Lancet, 360, 1242.
8. Coils , J. J., & Micallef A. (1997). Towards Better Human Exposure Estimates for Setting of Air Quality Standards. Atmospheric Environment, 31(24), 4253.
9. CPCB: (2013) Guidelines for the Measurement of Ambient Air Pollutants, National Ambient Air Quality Series: Volume-II, NAAQMS/37/2012-13.
10. Cunningham (2005). Notes on education and research around architecture. The Journal of Architecture 415-441.
11. Cunningham, B., Cunningham, M. A., & Saigo, B. W. (2005). Environmental Science: A Global Concern (8th ed.). Boston: McGraw Hill.
12. Enger, E.D. and Smith, B.F. (2003) Environmental Science: A Study of Interrelationships. 8th Edition, McGraw Hill Higher Education, New York.

13. Ghorani-Azam A, Riahi-Zanjani B, Balali-Mood M (2016) Effects of air pollution on human health and practical measures for prevention in Iran Journal of research in medical sciences. The Official Journal of Isfahan University of Medical Sciences 21:65.
14. Hamra GB, Laden F, Cohen AJ, Raaschou-Nielsen O, Brauer M, Loomis D (2015) Lung cancer and exposure to nitrogen dioxide and traffic: a systematic review and meta-analysis. Environ Health Perspect 123: 1107–1112.
15. India Meteorological Department, Satna (M.P.)
16. Kaushik, C.P., Ravindra, K. and Yadav, K. (2006). Assessment of ambient air quality in urban centres of Haryana (India) in relation to different anthropogenic activities and health risk. Environ. Monitor. Assess.122: 27-40.
17. Latif M.T., Huey L.S., Juneng L. (2012) Variations of surface ozone concentration across the Klang Valley, Malaysia. Atmos Environ 61:434-445.
18. Ling, O.H.L. (2012). Air Quality and Human Health in Urban Settlement: Case Study of Kuala Lumpur City. PhD Thesis: Universiti Kebangsaan Malaysia.
19. Miller, C. (1997). Toxicant induced loss of tolerance: An emerging theory of disease?. Environ. Health. Perspec.105 (2): 445-453.
20. Mills, N.L., Amin, N., and Robinson, S.D. (2005). Do inhaled carbon nano particles translocate directly into circulation in human circulation. Assess. J. Respir. Crit. Care Med. 173: 426-431.
21. Pope, C.A., 3rd; Thun, M.J.; Namboodiri, M.M.; Dockery, D.W.; Evans, J.S.; Speizer, F.E.; Heath, C.W. (1995) Particulate air pollution as a predictor of mortality in a prospective study of US adults. Am. J. Respir. Crit. Care Med., 151, 669–674.
22. Sadhana ChaurasiaS., Tiwari A.K., Arvind Singh Yadav A.S., 3 & Gupta A.K. (2020). Study on Ambient Air Quality of Satna City M.P., International Journal for Scientific Research & Development| Vol. 8(9): 2321-0613.
23. Sarah, Quarmby., Georgina, Santos., Megan, Mathias., (2019).Air Quality Strategies and Technologies: A Rapid Review of the International Evidence. Sustainability, 11: 2757.
24. Shaharukh M., Prerana P., Ahmed A.Y., Prasadkumar T., Ahmad A., Mohd A. Razi, S Hifjurrahman, Asif S. (2020). Impact of Air Pollution on Human Health. Bull. Env. Pharmacol. Life Sci., 9[7] : 91-97
25. World Health Organization (WHO) (2016). Household air pollution and health. Retrieved from www.who.int/mediacentre/factsheets/fs292/en.
26. Zivin JG, Neidell M (2012) The impact of pollution on worker productivity. Am Econ Rev 102:3652–3673.