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Impact of Incineration and disposal of Biomedical waste on Air quality in Gwalior city

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ABSTRACT: This study examined the atmospheric pollution created by biomedical waste incinerators and disposal facilities in the Gwalior city. Air monitoring was conducted in different places particularly near bio medical waste incinerator of Jaya Arogya Hospital and waste dumping site. Air measurements were made over a period of 3 months in 2016 and 2017. Samples of SPM, SO_2 and NO_2 were collected from ambient air surrounding the incinerator and dumping site. The results obtained from this study have indicated the presence of SPM, SO_2 and NO_2 in air surrounding the waste treatment and disposal facilities. In some cases the levels exceeded the concentration limits specified by the air quality standards and offensive odors were also detected. For the location of such facilities in the urban area, an adequate distance from residential buildings is desirable to minimize the risk of elevated concentrations of certain substances in air. The study revealed that adverse environmental impact of air pollutants may be a concern for the residents living in close proximity of incinerator.

Key words: Pollution, incinerator, waste, pollutant, air quality.

I. INTRODUCTION

The biomedical waste refer to all wastes generated by healthcare units during the provision of health-care services, including infectious and non-infectious waste materials, hazardous wastes and chemicals, and other non-hazardous wastes [1]. Hospital wastes are a mixture of general refuse, laboratory and pharmaceutical chemicals and containers, and pathologic wastes. The irrational waste management of health-care wastes from hospitals, clinics, and other health facilities cause occupational and public health problems to patients, communities, waste handlers and haulers, health workers and the environment. Although, 75%-90% of hospital waste is nonhazardous and harmless like other municipal wastes, the remaining 10%-25% is considered as hazardous to humans or animals and deleterious to the environment [1], thus, hazardous wastes require specific treatment and management before its final disposal [2]. The preliminary planning for waste management estimation indicates that the 80 % of the biomedical waste is general health-care waste followed by 15% pathologic and infectious wastes, 1% sharp wastes, 3% chemical and pharmacologic waste and 1% special wastes (cardioactive, cytotoxic, pressurized container) [3].

Thus, the separation, removal, and control of these infectious and pathologic wastes are of utmost importance. Incineration is burning process involves the chemical reaction of combustible waste materials with air, it destructs and reduce size and mass of the combustible material [4-5]. Incineration is the method of choice of health facilities for the treatment of infectious waste. The World Health Organization's 2004 policy paper and the Stockholm Convention, however, raised concern, namely, the need to consider the risks associated with the incineration of health-care waste [6]. It has been found that a medical waste incinerator releases into the air a wide variety of pollutants depending on the composition of the waste, which leads to health deterioration and environmental degradation. The significant pollutants emitted include particulate matter (PM) [1], metals [2], acid gases [3], oxides of nitrogen (NOx) [4], carbon monoxide (CO) [5], organic compounds [6], and other various materials present in medical wastes like pathogens, cytotoxins, and radioactive diagnostic materials [7]. PM is emitted as a result of the incomplete combustion of organic compounds and non-combustible ash. The concentrations of hydrogen chloride (HCl) and sulfur dioxide (SO_2) depend on the chlorine and sulfur content of the waste.

Sulfur and nitrogen chemically bind with the materials making up medical waste and are oxidized during combustion, forming SO_2 and NO_x, respectively (viz. NO and NO_2). CO is a product of incomplete combustion. Its presence can be related to insufficient oxygen, combustion (residence) time, temperature, and turbulence (fuel/ air mixing) in the combustion zone.

The incineration of hospital wastes not only releases toxic acid gases (CO, CO_2, NO_2, SO_2, etc.) and dioxides into the environment but also leaves a solid material, ash, as residue, which includes bottom ash and fly ash, which increases the levels of heavy metals, inorganic salts, and organic compounds in the environment [7]. Furthermore, innumerable substances with unknown toxicity are emitted. The entire impact on human health of exposure to the whole mixture of chemicals emitted from incinerators is unknown.

Human exposure to air pollution is believed to cause severe health effects, especially in urban areas where pollution levels are often high. However, health effects may also be significant when they cannot be detected as easily as in connection with such a severe episode. Studies of long-term exposure to air pollution suggest an increased risk of chronic respiratory illness [8] [9] [10] and of developing various types of cancer [11] [12] [13]. In an apparently worst case scenario carried out on the WHO data sets, [14] found that 6% of deaths in Austria, France, and Switzerland might be associated with exposure of the population to particulate air pollution. Many factors influence human health, and a good assessment of human exposure is crucial for a proper determination of possible links between air pollution and health. The air quality in small cities is also deteriorating due to different factors and incineration of biomedical waste is one among them. Hence, the objective of the current study is to assess the air quality of Gwalior city with special reference to biomedical waste incineration.

II. METHODOLOGY

Three sites were selected to monitor the air quality in Gwalior city

1. Site I -Waste disposal site
2. Site II- Kampoo
3. Site III- Near Incinerator

A. Monitoring of SPM

Air sampling of the different sites of the Gwalior city was done for the study of ambient air quality. It is very important to know that the various factors related to it and depends on the location of sampling station, size of the site sampling, duration and rate of sampling [15] [16]. Based on this sampling criterion, three sampling stations (Waste disposal site, Kampoo and JAH incinerator in Gwalior City) were selected for present study. The air sampling was carried out in accordance with the CPCB 2009 by using Handy air sampler (POLLTEC PEM-PGS1B). Monitoring of SPM was carried out for 24 hours with 8-hourly sampling. SPM was measured gravimetrically with Whatman 37 mm filter papers using Handy Air sampler.

B. Monitoring of Sulphur dioxide Sulphur dioxide content in the ambient air was measured by the modified West and Gaeke method [17]. The samples of sulfur dioxide (SO_2) were collected in glass impingers using a solution of 0.04M sodium tetrachloromercurate at an average flow rate of 1 liter per minute (1 L/min), resulting in the formation of dischlorosulphitomercurate complex. The sampling has been carried out for the duration of 24 hours at regular intervals of 4 hours at each site on monthly basis for a period of 3 months in 2016 and 2017 *i.e.* August 2016 to October 2016 and August 2017 to October 2017. A container (Ice box with eutectic cold packs instead of ice) with maintained temperature of 5 ± 5°C was used for transporting the sample from the collection site to the analytical laboratory. The main interference is due to the oxides of nitrogen which can be prevented by adding sulphamic acid, which acts as a reducing agent and converts some of the oxygenated nitrogen species to nitrogen gas. Ozone, trace metals also acts as an interfering agent, interference from trace metals can be prevented by adding EDTA (disodium salt) to the unexposed absorbing solution. For analysis, the exposed sample is treated with sulphamic acid, formaldehyde and acid bleached Pararosaniline containing hydrochloric acid. Pararosaniline, formaldehyde and bisulfite anion react to form violet red colored Pararosaniline methyl sulphonic acid, which was analyzed spectrophotometrically with the help of SHIMADZU UV Spectrophotometer (UV-1800) [18].

C. Monitoring of Nitrogen dioxide

Ambient nitrogen dioxide (NO_2) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite at an average flow rate of 0.2 to 1 L/min. The concentration of nitrite ion (NO^-_2) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl)- ethylenediamine di-hydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540 nm.

The concentration of NOx was measured with standard method of [19]. The concentrations of these methods were expressed in µg/m^3.The average data have been statistically analyzed.

III. RESULTS AND DISCUSSION

Hospitals in Gwalior are among the busiest hospitals with a highest patient load of JAH of about 1500-1800 patients per day and the average load of Gwalior hospitals is 100-300 patients/day for 2,032,036 inhabitants. Gwalior region is served by large general hospitals and nursing homes. These hospitals do not have their own facilities for the incineration of medical waste and only JAH hospital has incineration facility which is not sufficient to meet the demands of all hospitals. The waste includes anatomical waste, pathological waste, infectious waste, hazardous waste and other waste which is not often segregated properly and hence, the emissions caused by the incineration of medical waste depend not only on the incineration conditions, but also on the waste characteristics.

The maximum concentration of SPM was 262.12 and 169.00 (µg/m³) recorded at S2 and S1 in October 2016 and 2017 and the minimum concentration of SPM was 54.12 and 56.75 found in S1 and S3 August 2016 and 2017. The average concentration of SPM during 2016 and 2017 was 71.96±9.09, 135.46±4.33, 226.16±18.42 and 87.67±15.75, 144.37±10.90, 153.33±7.84 respectively (Table 1&2 and Fig 1&2).

Table 1: Average concentration (µg/m³) of SPM at different locations of Gwalior City during 2016.

2016	Site I	Site II	Site III	Average
August	54.12±3.60	77.88±15.01	83.88±8.72	71.96±9.09
September	143.62±17.08	128.88±12.59	133.88±7.71	135.46±4.33
October	201.25±19.71	262.12 ±10.13	215.12±27.74	226.16 ±18.42

Table 2: Average concentration (µg/m³) of SPM at different locations of Gwalior City during 2017.

2017	Site I	Site II	Site III	Average
August	97.88±15.55	108.38±15.58	56.75±10.57	87.67±15.75
September	125.62±19.14	163.38±17.72	144.12±25.28	144.37±10.90
October	169.00±14.22	145.12±13.34	145.88±23.21	153.33±7.84

Fig:1 Concentration of SPM (µg/m³) at different sampling sites during 2016

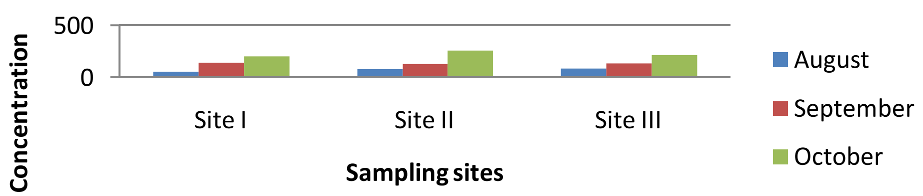
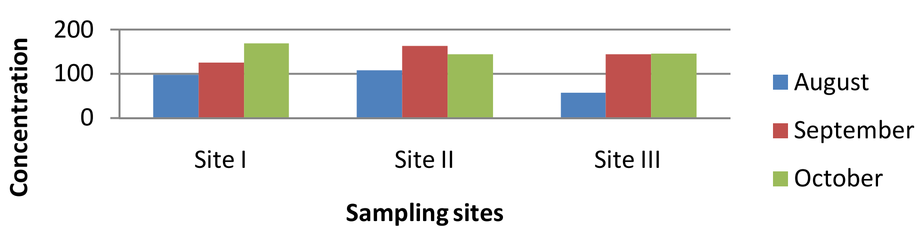


Fig: 2 Concentration of SPM (µg/m³) at different sampling sites during 2017



The maximum concentration of SO_2 was 17.35 and 11.46 (µg/m³) recorded at S3 in October 2016 and 2017 and the minimum concentration of SO_2 was 5.68 and 5.85 found at S1and S2 in September 2016 and October 2017 respectively.

The average concentration of SO_2 2016 and 2017 was 8.73±1.89, 8.47±10.40, 14.09±1.63 and 7.54±0.78, 9.36±1.39, 8.46±0.63 respectively (Table 3&4 and Fig. 3&4).

Table 3: Average concentration (µg/m³) of SO_2 at different locations of Gwalior City during 2016.

2016	Site I	Site II	Site III	Average
August	6.58±0.53	7.11±0.83	12.50±1.92	8.73±1.89
September	5.68±0.55	9.62±1.51	10.12±2.06	8.47±10.40
October	12.43± 2.38	12.50±1.92	17.35±4.32	14.09±1.63

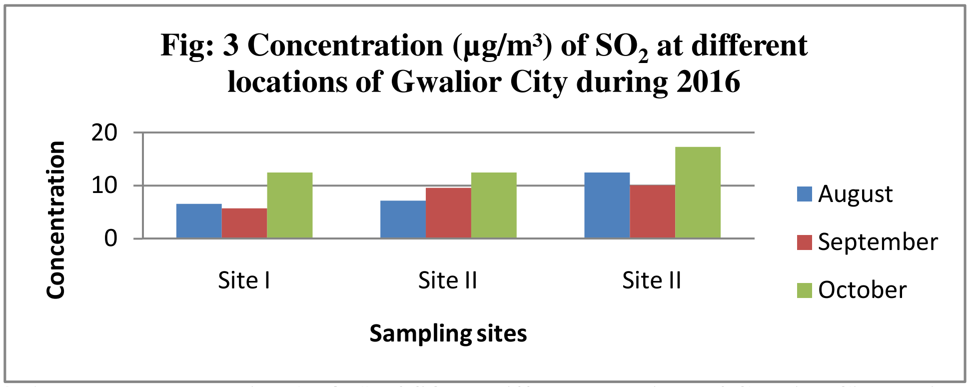
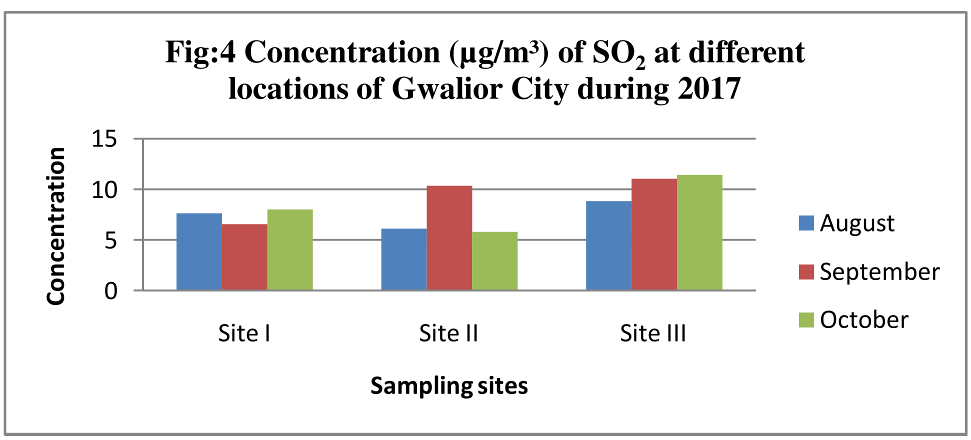


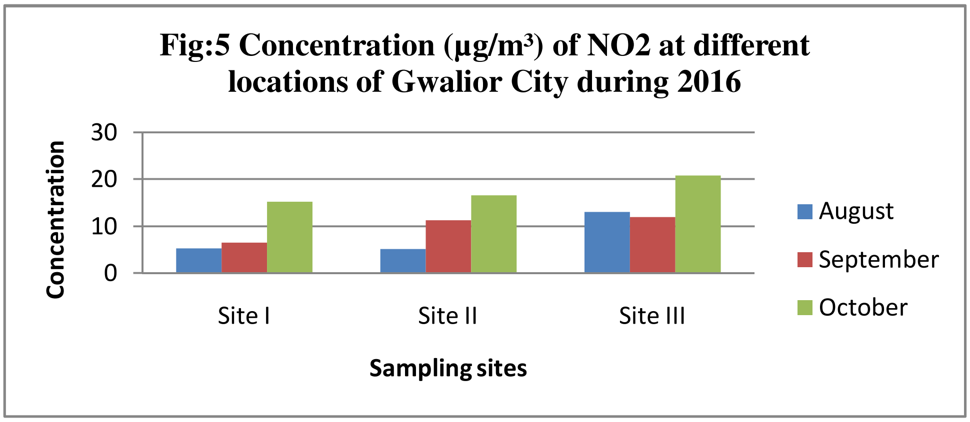
Table 4: Average concentration (µg/m³) of SO_2 at different locations of Gwalior City during 2017.

	Site I	Site II	Site III	Average
August	7.66±0.91	6.14±0.63	8.83±1.62	7.54±0.78
September	6.60±1.13	10.38±2.20	11.09±2.04	9.36±1.39
October	8.06±0.88	5.85±1.49	11.46±1.96	8.46±0.63

Table 5: Average concentration (µg/m³) of NO_2 at different locations of Gwalior City during 2016.

2016	Site I	Site II	Site III	Average
August	5.36±1.11	5.15±0.51	13.05± 2.67	7.85±2.60
September	6.58±0.73	11.32±4.10	12.04±0.58	9.98±1.71
October	15.22±3.36	16.68±4.06	20.82±1.30	17.57±1.68

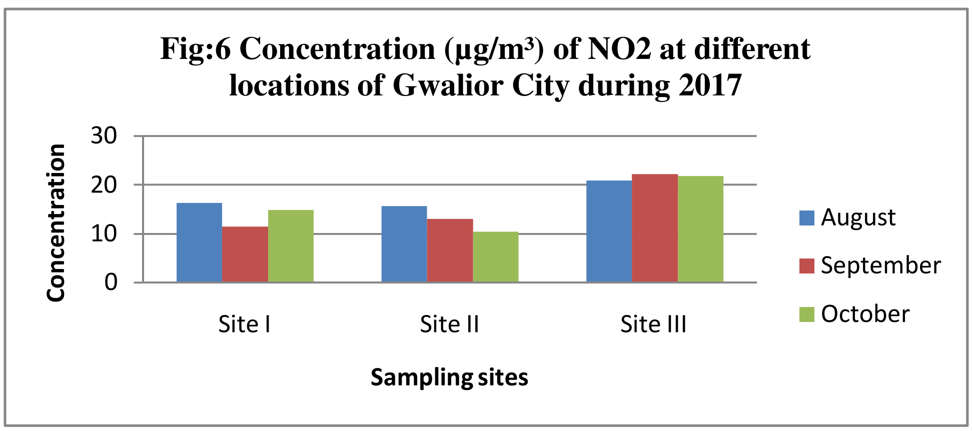




The maximum concentration of NO_2 was 20.82 and 22.28 (µg/m³) recorded at S3 in October 2016 and September 2017 and the minimum concentration of NO_2 was 5.15 and 10.37 found at S2 in August 2016 and October 2017 respectively. The average concentration of NO_2 2016 and 2017 was 7.85±2.60, 9.98±1.71, 17.57±1.68 and 17.64±1.68, 15.60±3.37, 15.73±3.35 respectively (Table 5&6 and Fig. 5&6).

Table 6: Average concentration (µg/m³) of NO_2 at different locations of Gwalior City during 2017.

2017	Site I	Site II	Site III	Average
August	16.27± 1.76	15.67±3.15	20.98± 3.95	17.64±1.68
September	11.44±3.12	13.09±2.00	22.28±3.66	15.60±3.37
October	14.92±1.35	10.37±0.88	21.90±3.09	15.73±3.35



Incineration and disposal is the only most widely used treatment technology for the disposal of medical waste in Gwalior. The major advantages achieved through incineration and disposal is the significant reduction in the volume of material, and destruction of pathogens and hazardous organics. However, main disadvantage is that incineration may emit different unwanted pollutants such as polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzo–furans (PCDF), usually in cities due to the typical location of hospitals [20].

The results were found significantly higher near the incinerator and subsequently the comparison with other sampling sites with respect to PM, SO_X and NO_X was very less at other sites. The Gwalior was designated as one of most polluted city of the world by WHO in [21]. Although, the PM near incinerator site and the dumping region was not at such concentration which was expected. The influence of temperature and wind direction is obvious but was not quantified by the practical study.

The high concentration of gases near the waste incinerator and dumping sites is very unhealthy for the residents and will decrease the air quality index of the region and hence urgent action is needed and it is recommended to use incinerator that have better efficiency to convert waste into energy. However, it is observed that during the closure of medical waste incinerator, a reduction in the amount of PM, SO_x and NO_x has been observed. Hence, it is expected that the amount of other pollutants like dioxins, PAH, Furans will also decrease.

The other concern that adds to the atmospheric pollutants is the unregulated mining in Gwalior. The mining in Gwalior near is carried out throughout the year. Further, a major secondary pollution source of atmospheric pollution in Gwalior is the household wood burning for heating to cook food. Burning of wood at very low temperature with a low burning efficiency may also increase the level of pollution. Further, variation in the amount of pollutants has been observed during different seasons. The concentration of the different gas substances was higher during winter due to inversion similar results were obtained by [22] the concentration of pollutants during summer is low due to atmospheric currents and turbulence. The similar result has been reported by other workers [23, 24, 25].

CONCLUSION

The study found that the burning of hospital waste is an additional source of air pollution in Gwalior city that affects its air quality. The study found negative environmental impact of air pollutants which may be a concern for the residents living in close proximity of incinerator.

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