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Effect of Heavy Metals caused by E-waste Activities on Soil Samples, $PM_{2.5}$, Human Fingernails, and Scalp Hair in Moradabad City, India

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Abstract

E-waste is a popular name for electronic products nearing the end of their favorable life. Which ensuing in increased dangers of digital waste normally acknowledged as e-waste. Present study was aimed to find out the soil quality, air pollution and its relation to human health risk. Therefore, two study sites (SI and SII) were choised on the basis of various activities. $PM_{2.5}$ air samples had been gathered with the help of RDS after which were analyzed to heavy metals through ICP-MS. Objectives of the study, was to generate baseline data at the quantity of heavy metal cognizance in soil from two test sites. In rise, we measured the heavy metallic concentrations in scalp hair and fingernails to discover if there exists any relation among organic publicity and environmental. Hypertension, Hypoxemia and Asthma had been additionally decided for the evaluation of fitness parameters among the take a look at population. For this purpose, investigation also involved the collection of fingernails and scalp hair for heavy metal analysis (ICP-MS) from human subjects of two study sites. Results indicated that, except SI, SII had significant level of $PM_{2.5}$ and its heavy metal content. All soil indices which were employed to determine the level of pollution, indicates extreme level of metals at all the study sites. Therefore, local residents as well as workers, who were engaged in e-waste burning and industrial activities also had various levels of toxic metal concentrations in their scalp hair and fingernails. We concluded that the high levels of air pollution, containing toxic metal pollutants such as Pb, Zn, Cu and Ni released from e-waste burning activities, resulted in significant health risks for the exposed human population.It is recommended that environment of Moradabad City should be closely monitored by government agencies on routine basis. It was concluded that the toxic metal contamination imposed a negative influence on the environment, soil and human health.

Keywords: Heavy Metals, E-waste activity, $PM_{2.5}$, Soil, Human Fingernails, Human Scalp Hair and Human Health

1. Introduction

The electrical waste and electronic equipments (EEEs) contain several substances, many of which are toxic in nature and could be hazardous for the environment, especially soil and human health[1]. Electronic waste is a plausible name that includes Cell phone, old computers, televisions, printers, etc. Toxic metals are found on a massive scale in e-waste, mainly Pb, Cr, Ni, Zn and Cu as nicely as several different metals that may affect the environment. E-waste production is anticipated at 20–50 million tons, depict 1–3% of the overall waste generated every year worldwide[3].

Assessment of toxic metal concentrations for exposed workers is important in order to monitor these metals impact on human health. In recent years, interest in scalp hair has increased in the humanitarian body as a bioindicator of contaminants[7]. Nails have seemed like a terrific bioindicator for one-of-a-kind poisonous factors wherein people were uncovered to those factors for the time period of two to 18 months[9]. Heavy metal released from the uncontrolled open burning of electronic waste could penetrate into the soil. The presence of heavy metal may adversely affect soil microbial population, their activity and performance. The toxic metals

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deposited in soil inter-aggregate soil material and accumulate in plant root zone and so they get easily accessible for plants[6].

In India, there are numerous websites recognized for the recuperation of valuables substances from e-wastes. In Moradabad, the high center wherein e-waste recycling most chiefly through the open burning of apparently printed circuit boards (PCB)[10]. These activities additionally pose an excessive risk to public fitness and environment. E-waste burning produced fine particulates matter, which is linked to lung, cardiovascular and pulmonary disease[11]. Particulate pollutants is primary indicator of air pollutants. And one day's e-waste recycling substantially make contributions in deterioration of air quality[12].

The primary objective of the existing examination into to decide the heavy metal in fingernails and scalp hair of local residents citizens in an e-waste burning area to estimate the heavy metals exposure. Toxic metals concentrations had been analyzed in the soil and $PM_{2.5}$ samples of study sites. The variation of the bodily situation of toxic metals concentrations after exposure to e-waste reusable process was also estimated by comparing with citizens dwelling place in a nearby city. So, present study deals with the assessment of prevailing concentrations of heavy metals in ambient air ($PM_{2.5}$) and human population of different areas of Moradabad City where illegal e-waste burning and industrial activities are most common anthropogenic activities.

2. Materials and Methods

2.1 Selection of Study Sites

Two monitoring stations of Moradabad city were selected based on the vehicular, predominance of residence and e-waste burning, and recycling activities in the study areas (Figure 1). The brief description of study locations are described here; **Site I (SI, Didaura)** – This is purely residential cum industrial & commercial activities area. **Site II (SII, Mugalpura)** – This site is a e-waste burning activities area.

2.2 Sampling Method and Analysis of $PM_{2.5}$

$PM_{2.5}$ samples were gathered from two sites during camp, i.e. from 27th February to 7th March 2019. Samples of $PM_{2.5}$ were gathered by gravimetric method (GM) with the assist of the FPS (Fine Particulate Sampler) APM 550 machine in 24 hours. PM particles were collected by filter paper, which was used for the calculation of the 24 hours average. This research was completed under the Central Pollution Control Board (CPCB) of India guidelines.

$PM_{2.5}$ concentrations was calculated by the following equation:

$$PM_{2.5}(\mu g/m^3) = \frac{(W_2 - W_1) \times 10^6)}{V}$$

Where,
W_1 = Initial weight of the filter paper (IWFP)
W_2 = Final weight of the filter paper (FWFP)
V = Volume of DGM (Dry Gas Meter)
(*= Hours, **=Minute, ***= Average)

Evaluation of poisonous heavy metals concentration, overall 10 (2 tracking stations + 1 blank) of the GF-A filter paper included with the aid of using particulate matter digested with nitric acid and perchloric acid in a ratio 1:3 on a 1400C warm plate until white fumes come out. After this, the solution was re-dissolved in 0.1M hydrochloric acid and

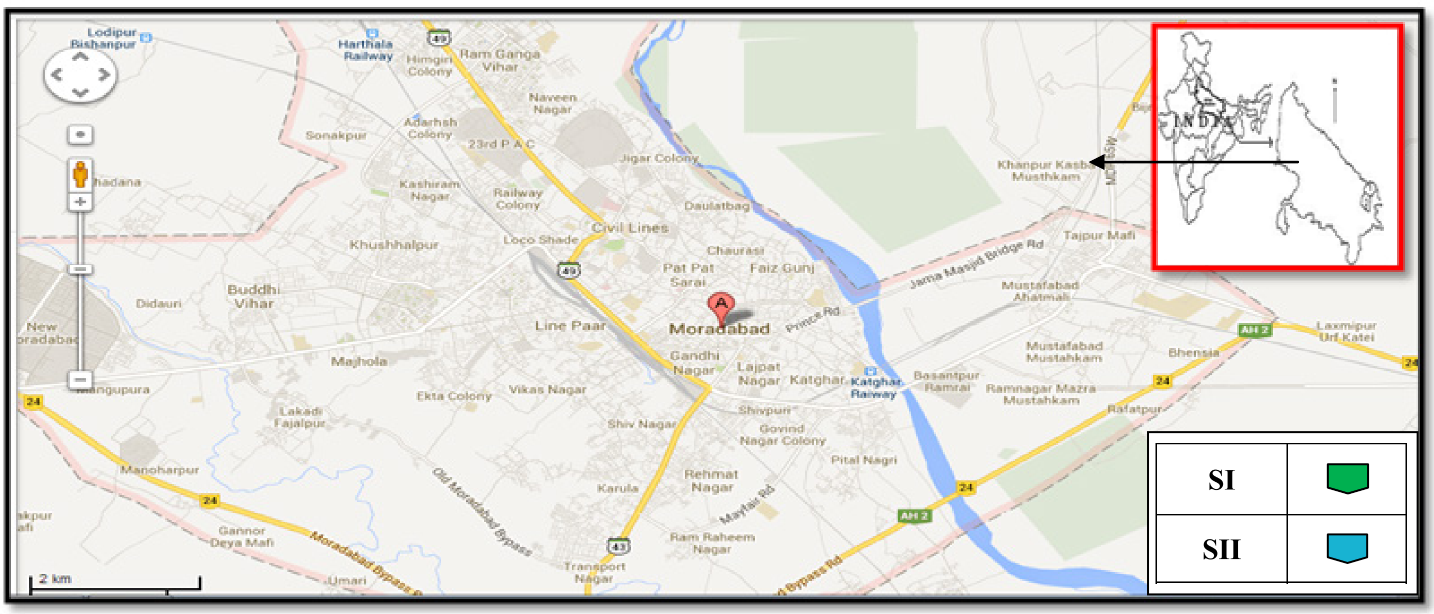

Figure 1. Map of study sites.

filtered with filter paper (no. 42). Finally made up to 25 ml with double distilled water. The sample was ready for the analysis of heavy metals i.e. Cr, Ni, Zn, Cu and Pb by using (ICP-OES) Inductively Coupled Plasma-Optical Emission Spectrometer.

2.3 Analysis of Soil Samples

Soil samples were collected from e-waste and residential area. At sampling sites, about 250g of composite soil samples were collected, a soft touch brush was used for massive and plastic dust pan for collection, separate plastic bag was used for sampling collection from each site. A minimum of five samples were collected from each points, with the distance of some kilometers in the same selected area. The samples were labeled carefully and taken to the Pollution Ecology Research Laboratory of Moradabad for further analysis. For digestion process 0.5 g of dry soil was weighed and digested with 15ml of concentrated HNO_3 , H_2SO_4 and HCl (5:1:1) at 80°C until the clear solution was obtained. Digested soil samples was cooled and filtered by using Whatman filter paper. The further filtrate was diluted with de-ionized water and kept at room temperature. For analysis of heavy metal concentration ICP-MS (Inductively Coupled Plasma Mass Spectrphotometer) was used.

2.4 Contamination Factor

Contamination factor of heavy metal was calculated by the following formula according to[16] .

CF = Cm Sample/Cm Background

Where, Cm Sample = the sample concentration of heavy metal in the soil samples

Cm Background = the background concentration of the heavy metal.

Background value of Pb are given on the basis of[17]. Cu, Zn, Ni, Cr are given on the basis of background values of[18]. Calculation of soil indices on the basis of the concentration of toxic heavy metal represented in Table 2.

Table 1. Background Values of Heavy Metals

Elements	Pb	Cu	Zn	Ni	Cr
Background Values (mg/kg)	20	55	70	75	100

Table 2. Classes of soil indices with respect to soil quality

Class	Soil Quality Index	Contamination Factor (CF)
1	<1	Low contamination
2	1≤ to < 3	Medium contamination
3	3≤ to ≤6	Considerable contamination
4	>6	Very high contamination

2.5 Ethical Approval

Center of Nutrition Research, Halberg Hospital and Research Institute, Moradabad (U.P.) approved the study design and protocol.

2.6 Methodology for Health Study

2.6.1 Research Design and Samples Selection

Subjects have been chosen base on the random sampling technique. After this, fitness survey camps were organized in selected areas. Before first, fitness survey camps were organized in selected areas. A total of 48 subjects were agreed to giving samples of the fingernails and scalp hairs, in which 24 subjects from SI and 24 from SII. The participants provided health information for the consent form. The participant's ages ranged between 18–60 years. In exclusion standards' subjects were selected only males, which connected to e-waste burning and recycling. In inclusion standards had been of persons, without any chronic illness such as sugar, diarrhoea and cancer.

2.6.2 Health Parameters

We had measured Expiratory Flow Rate by Mini Wright PEF meter. At 3 time measurement, the higher value of PEFR was noted[21]. The ordinary PEFR values will range relying upon an man or woman's age, height and weight, even the time of day. An analysis of 400-600 l/min is taken into consideration ordinary, suffering from asthma might have a lower range to 200-400 l/min. Physical check up Body mass index (BMI), Height (cm) and weight (kg) and blood pressure measured according to[10].

2.7 Fingernails and Scalp Hairs Samples Collection Method and Analysis

Fingernails (n = 24) and hair samples (n = 24) were collected in March 2019 from people living in the e-waste burning area. For comparison, fingernails and hair samples were also collected from an industrial and commercial activities area. Fingernail samples were collected by nail clipper and separately stored in labeled zip polyethylene bags.

Fingernails samples were cleaned 3 times rinse with water and dried at room temperature. After this, 1 ml concentrated HNO_3 was added and the tubes were capped and left for 48 hours. After this, these samples were diluted with 9 ml of deionized water. After this, the decant with the help of fresh acid-cleaned polypropylene tube. Finally, ICP-MS was used for the analysis of these solutions. The dry **hair samples** were cut into 2-3 cm lengths and 20 mg hair samples were collected in a plastic zip bag. Samples were rinsed two time in de-ionized water and dried with the help of clean and thin layer paper.

After this, hair samples were rinsed with the help of 0.3% polyoxyethylene lauryl ether in a sonicator and digested with HNO_3. Finally, TEs concentrations (Cr, Cu, Zn, Pb and Ni) were measured by ICP–MS.

2.7 Statistical Analysis

The data were analyzed with help by SPSS WINDOWS, version 20.0 statistical software. Basic statistical parameters such as mean, standard deviation,'t' test and one-way ANOVA were calculated for the influence of the heavy metals concentrations.

3. Results and Discussion

3.1 Mean Concentration of Heavy Metals in $PM_{2.5}$

The metals concentration in $PM_{2.5}$ observed from ambient air from various study sites is represented in Table 3. The highest concentration of $PM_{2.5}$ was obtained (210.85 ± 50.51 µg/m^3) at SII whereas lowest (109.91 ± 11.13µg/m^3) at SI. Which exceeded the National Ambient Air Quality Standard (NAAS) value i.e. 60µg/m^3 given by[23]. Because wind levels and a drop in temperature in this winter season follow the pattern of high levels of pollution[24]. An increase in $PM_{2.5}$ concentration was showed might be attributed to the anthropogenic activities such as the burning of traffic emissions, high traffic density and combustion of fossil fuel, etc in winter season[25].

The maximum mean concentration of Cu (185.11 µg/m^3) and Zn (2458.10 µg/m^3) was observed at SII while the minimum at SI. Cu and Zn mixed easily with each other as in brass. Pursuance to e-waste guideline (2013), Cu and Zn constitute about 6.95 and 2.2% of the composition of PCBs. Informal recyclers used recycling processes like acid baths and burning to recover precious metals from PCBs. These similar results were also reported by[27].

The maximum mean concentration of Pb in $PM_{2.5}$ samples was found at SII where illegal e-waste burning is frequently done by informal recyclers. Pb is the main constituent of PCBs. Therefore, during this procedure, toxic fumes are released into the environment leading to consideration in the meteorological concentration of Pb[4]. Nickel originates from the burning of fossil fuel and especially the smelting of oil in the atmosphere[28]. The possible sources of Cr in the study areas are the use of oil lubricants at service centers and vehicle exhausts. Ni and Cr are also used as one of the main alloys of brass, hence industrial activities are also responsible for a higher concentration of these metals in the air. Therefore study revealed that Zn, Cu, and Pb were the major components of the heavy metal load in $PM_{2.5}$ of all study sites[12] also concluded that uncontrolled e-waste activities release toxic metals such as Hg, Ni, Cr, Cu, Pb, and Zn.

Table 3. Mean concentrations of studied heavy metal in ambient air ($PM_{2.5}$) of two sites

Sites	$PM_{2.5}$ Mean value and SD of 7 days	Heavy Metal Concentrations in $PM_{2.5}$ (µg/m^3)				
		Cr	Ni	Cu	Zn	Pb
SI	109.91 ± 11.13	106.69	19.81	151.81	1758.10	491.83
SII	210.85 ± 50.51	149.58	60.24	185.11	2458.10	707.80

3.2 Heavy Metals Concentration in Soil

Contamination factor of soil caused by different heavy metals is presented in the Table 4. Lead (Pb) at two different study sites are classified in class 4 (represents high contamination) while Pb at SII is classified in class 2 category (represents very low contamination). It is one of the most commonly used heavy metals used in both computer and television screens, and in the solder used to anchor various circuit board components[29]. High contamination of soil by Pb may be due to the disposal of cathode ray tubes, printing wiring boards and acid lead batteries, incandescent light bulbs directly on the soil after recovery of metals or even the burning of printed circuit boards. Recycling of computer monitor for extracting the valuable metals is also increases the concentration of Pb in the soil because it consists glass panels and gaskets monitors which have the high concentration of Pb. Short-term exposure to high levels of Pb can cause vomiting, diarrhoea, convulsion, coma, headache, sleeplessness etc. while long-term exposure damage vital organs and also reduce the IQs and understanding capabilities of children[30].

The contamination factor (CF) for Cu and Zn at two different study sites are classified in Class 2 represents a very

Table 4. Heavy metal concentrations and CF values in soil samples at various study sites

Heavy Metal	STUDY SITES				
	SI Mean±SD	Contamination factor (CF) at SI	SII Mean±SD	Contamination factor (CF) at SII
Cr	45.8 ± 22.8	0.46	353.3 ± 47.4	3.53
Ni	28.7 ± 6.7	0.38	653.5 ± 150.2	8.71
Cu	26.7 ± 8.0	0.49	1302.9 ± 448.2	23.69
Zn	121.4 ± 46.3	1.74	1457.3 ± 475.1	20.82
Pb	60.7 ± 9.4	3.04	962.6 ± 173.1	48.13

high contamination, except at SII which is further classified in Class 2 representing a moderate contamination (Table 2). The major sources of Cu are vehicular emission and industrial activities along with e-waste processing activities such as direct heating, burning and other chemical processes to recover materials from semiconductor chip, photocopy machine, computer monitor and cell phones etc. These are known to induce carcinogenic effects in humans through inhalation[31] and also shows negative effects on the reproductive health. Arsenic is used in semiconductors, diodes, LEDs, solar cells of e-waste and it is toxic to both plants as well as animals while inorganic arsenicals are proven carcinogens in human health and[32]. The contamination factor for Ni at SI is classified in Class 1 represents low contamination, while SII is placed in Class 4 category representing a very high contamination. Nickel (Ni) is an important component of the computer monitor, cell phones, PCBs. The crude extraction methods of gold using Ni are contributing to low contamination in the soil of SI.

It is bio-accumulative in nature so accumulates in the food through the transfer from soil and affects the human health causing mental illness and DNA damage[33]. The results of degree of contamination showed that SII have very high degree of contamination, while SI have low degree of contamination. Results of one way ANOVA (Table 5) showed that study sites have a significant effect on all heavy metals in $PM_{2.5}$, soil, fingernails and scalp hair of the study population. This finding represented that the location of study sites influenced the biological levels of various heavy metals in the residents.

3.3 Heavy Metals Concentration in Human Nails and Scalp Hairs

The heavy metals concentrations in nail samples from different study sites are given in figure-2 (a) & (b). Concentration of Zn, Pb, Cu, Ni and Cr were ranged from 6.454-16.844, 0-0.678, 0.120-1.152, 0-0.354 and 0-0.0003 ppm among all studied subject from different study sites. The mean concentrations of all heavy metals were found highest in study population of SII

Table 5. ANOVA between heavy metal on different parameters for study sites

Parameters for Heavy Metals	Site I		Site II	
	F	Probability	F	Probability
$PM_{2.5}$ samples	23.16*	0.0001	32.73*	0.00001
Soil samples	11.17*	0.00005	12.16*	0.00007
Human fingernail samples	29.42*	0.00001	34.46*	0.00002
Human Scalp Hair Samples	26.88*	0.00006	39.55*	0.0004

(*) = significant and (F) = factor

whereas lowest in study population of SI (Figure. 2a & b). The highest mean concentrations of Cr, Ni, Cu, Zn and Pb in nails samples were found 40.78, 1285.10, 56.25, 805.66 and 60.41 ppm at SII while lowest 35.59, 794.67, 53.97, 486.16 and 21.97 ppm in study population at SI. These results demonstrate that the concentrations of heavy metals in e-waste workers fingernails are the highest values comparison other site. This may produce by exposure to welding smoke which represents a combination of very fine particles (fumes and gases, the fume contains toxic metals such as (Ni, Zn, Pb, Cu, Cr and Co)[34]. The current study reported that heavy metals concentrations were in order Ni>Zn>Pb>Cu>Cr at e-waste burning site. Ni is found inside the stream of welding fume and acid bath, and causes nasal lung cancer, also NIOSH (National Institute for Occupation Safety and Health) classified Ni and Pb as a human carcinogen[35]. Analysis of variance revealed that heavy metals were highly significantly affected at SII (e-waste burning site) for all parameters.

This study deals with the quantitive assessment of heavy metals (Pb, Zn, Ni, Cr and Cu) in fingernails of the subject in e-waste burning area using atomic absorption spectrometry. Metal concentrations in scalp hair samples collected from SI (residential site) and SII (e-waste site) are given in Figure 2(a) & (b) in mg/kg. It was recorded that the average Cr, Ni, Cu, Zn and Pb in hair samples from (SII) are 45.22, 1426.66, 70.77, 1168.89, 88.16 mg/kg as against the average of these metals in hair samples from (SI) 35.59, 885.67, 53.97, 562.73, 21.97 mg/kg respectively. This result confirmed that heavy metals concentration in human hair and nails depends on environmental divestment. In Ghana,[36] reported that the increased level of toxic heavy metals in hair of peoples with the direct impact of automotive exhaust and electroplating industries. In this study metal concentrations (cu and Zn) were

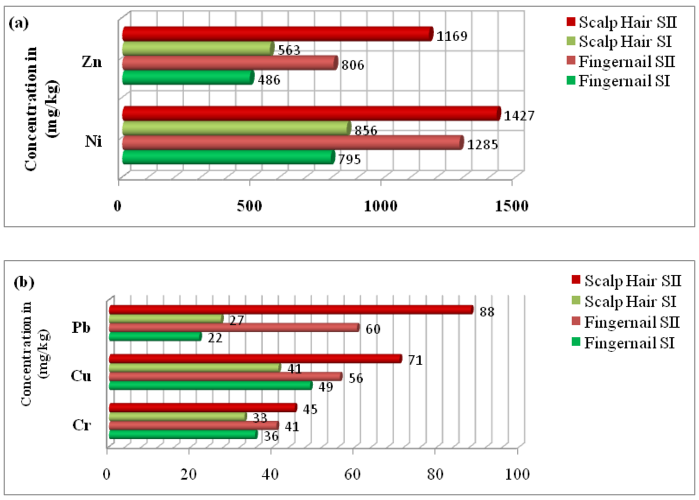

Figure 2(a) & (b). Mean concentration of heavy metals in human nails and scalp hair of different subject of study sites.

higher in the hair samples of the e-waste site (II). In our study comparing concentrations of heavy metals we found that Zn and Cu concentrations in hair were maximum than in nails[38].

3.4 Study of Human Health Status

The health status of different subjects from study sites is represent in Table 7. The SBP several between 103-201 mmHg in subjects of SI and 110-206 mmHg in subjects of SII while the DBP was ranging from 64 to 103 mmHg and 66 to 146 mmHg in subjects of SI and SII. Results represented that subjects of the SI were having normal average SBP and DBP. Although the subject of SII also has typical mean SBP and DBP, they still had a serious maximal possibility of developing heart disorder and were considered to be hypertensive as a result of their 66% dispersal of hypertension respectively (Figure 3). According to[39], hypertension may be described as a mean SBP ≥ 140 mmHg or DBP ≥ 90 mmHg and/or current use of antihypertensive medical stipulated by a doctor. Hypertension is the highest rampant disorder that causes negative effects on major organs, such as the kidney, heartbeats and arterial blood vessels, brain. Generally, the risk factors for blood pressure include stress, smoking, increasing age, diabetes, dyslipidemia, high BMI and lack of physical activity etc[40].

Analysis of the t-test revealed a highly valued difference in the event of hypertension between air sample particulate matter and blood pressure (SBP and DBP) at SII while low significant between particulate matter and blood pressure (SBP and DBP) at SI (Table 6). Industrial and commercial activities were found at SI. These consequences normally revealed that e-waste burning activities caused pollution at SII which was very harmful to residential persons. Strong significant association was found between mean ambient $PM_{2.5}$ levels with SBP and DBP with t-values 2.32* and 7.04* respectively (Table 6) at SII which exhibited that particulate matter levels were capable for the possibility of hypertension in studied population of all study sites[41].

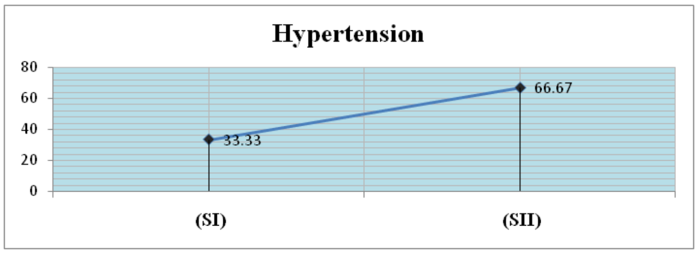

Figure 3. Dissemination of hypertension of two study sites

The PEFR is a necessary measurement instrument in the evaluation of the asthmatic patient. It is helpful in monitoring disease progression and response to treatment. Simple instrument-PEFR is used for the measurement of PEFR. The mean PEFR was observed 473.75 and 349.58 l/min for studied population of SI and SII respectively. In male, prediction equations were obtained for PEFR with height. Significant 't' test values were recorded for PEFR with height at SI (3.96*) and at SII (5.93*). Anthropometric, regional and environmental factors were also affect the reference values of PEFR[21].

Weight (kg) and height (m^2) of each subject were taken for the measurement of BMI (Bio Mass Index)[22]. Average BMI was found under the overweight category (23.10 kg/m^2) for the subjects of SI while the studied population of SII had normal BMI (18.07 kg/m^2). This study revealed that although the BMI means of subjects of SII was within the normal range but they still had a higher percentage of hypertension into the subject of study sites. It's might be responsible for some hazardous contaminants of the environment which plays an important role in hypertension other than a lifestyle. BMI and hypertension are positively associated. Besides this, these results also reported that high toxic metal concentrations of Ni, Zn, Pb and Cr detected at the SII site amongst all sites might be amenable for a high percentage of hypertension (Figure 3). Another researcher has also reported the role of toxic metals in the causality of hypertension[42].

Frequent cough, choking sensation severe shortness of breath after physical activity and shortness of breath in the resting stage, etc are related to low blood oxygen levels. Therefore, $PM_{2.5}$ is the main factor for lung cancer[46].

Table 6. t-test between air pollutants and various health measurements (1 tailed significant at the 0.05 level)

AIR POLLUTANTS	HEALTH MEASUREMENTS					
	SBP	DBP	SpO2	PR	BMI	PEFR
$PM_{2.5}$ (SI)	1.60^{NS}	5.67^*	1.74^*	7.03^*	9.58^*	3.96^*
Sig. (1-tailed)	0.63	0.53	0.31	0.08	0.32	1.12
$PM_{2.5}$ (SII)	2.32^*	7.04^*	7.25^*	7.11^*	11.44^*	5.93^*
Sig. (1-tailed)	0.72	0.58	0.42	0.10	0.37	1.23

*Sig = significant, NS = non-significant, * = Significant, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, SpO2 = Blood Oxygen Level, PR = Pulse Rate, BMI = Body Mass Index and PEFR = Peak Expiratory Flow Rate*

Table 7. Physical Health Characteristics from study sites of subjects

Physical Measurements	SI (Didora) (n=24)		SII (Mugalpura) (n=24)	
	Mean±SD	Range	Mean±SD	Range
Height (cm)	1.68 ± 0.08	1.5-1.82	1.65 ± 0.07	1.54-1.85
Weight (kg)	50.75 ± 5.97	45-71	52.63 ± 7.95	48-80
BMI (kg/ m^2)	18.07 ± 2.52	14.49-25.00	23.10 ± 3.32	15.61-29.76
SBP (mmHg)	132.96 ± 19.17	103-201	141.50 ± 28.00	110-206
DBP (mmHg)	86.67 ± 10.45	64-103	92.54 ± 20.35	66-146
PEFR (l/min)	473.75 ± 73.47	350-650	349.58 ± 93.92	180-530

SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, Rate, BMI = Body Mass Index, PEFR = Peak Expiratory Flow Rae, n = number, ± = Standard Deviation

4. Conclusion

We concluded that illegal e-waste burning activity has significantly contributed to the sublimate concentrations of $PM_{2.5}$. E-waste burning activities are very harmful to human health risks especially living people in resediantly areas. This process released harmful material such as toxic levels of heavy metals and PCBs. By e-waste burning activity, are released a toxic chemical into the air damaging the atmosphere. E-waste burning creates fine particulate matter created and which was responsible for the toxic levels of heavy metal exposure to the local residents, which is linked to pulmonary and cardiovascular, hypertension disease. Particulate matter concentrations exceeded from NAAQ standard given by CPCB (2009) whereas concentrations of gaseous pollutants found below from the prescribed limit at all the study site. Particulate matter concentration and e-waste burning activity plays a major role in causing lower PEFR in inhabitants of e-waste burning area. Due to the sublimate level of toxic heavy metals in contamination of soil and human fingernails and scalp hairs from e-waste processing area, the people living in study areas are suffering from many diseases. Since electrical and electronic equipments are the need of the hour to progress there should be guidelines for the proper disposal of e-waste. Workers should be trained to use environment friendly methods for recycling e-waste properly. The study educed that exposure to high level of air pollution, containing toxic metal pollutants such as Pb, Cu, Ni and Zn, released from e-waste burning activities, resulted into significant health risk for the exposed human population. It is recommended that environment of Moradabad City should be closely monitored by government agencies on routine basis. This study concluded that the exceedance of heavy metal contamination imposed a negative effect to the soil, air quality, human health and environment.

5. Acknowledgement

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