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Elemental and Organic Carbon, Ionic and Non ionic components in TSP and PM_{10} Particulates of Kathmandu Valley, Nepal

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Abstract: Particulate matters of different aerodynamic diameters; TSP, PM_{10} for 24 hours were collected on quartz 47mm filter paper using Frm OMNI™ Ambient Air Sampler from December 2010 to March 2011 and analyzed.The analysis of these sample collected were carried out by gravimetric, X-ray fluorescent and ion-chromatographic methods. TSP value for the observed period lies between 31.3-84.08 $\mu g/m^3$ while PM_{10} ranges from 39.5-104.2 $\mu g/m^3$. Daily carbonaceous aerosols concentration in TSP varied widely between (5.3-18.2 $\mu g/m^3$) for Organic carbon (OC) and 5.6-10.2 $\mu g/m^3$ for Elemental carbon (EC). Similarly in PM_{10} the range was from 4.8-14.1 and 3.9-10.1 $\mu g/m^3$ respectively. The OC/EC ratio in the particulate matters ranges from 0.9-1.4. OC/EC ratio within 1.1 infers vehicular emission as a major source of carbonaceous aerosols in the valley. Further, among the nonionic components analyzed (K, Ca, Fe, Ti and Pb) showed highest concentration of Fe as 2.5 $\mu g/m^3$ while lowest of Pb as 0.001 $\mu g/m^3$.The ionic components analyzed shows presence of $SO_4^{2-}$and NH_4^+ in most of the samples while Cl^-,NO_3^-andCa^{2+} are only in few samples. Few samples of soil analyzed shows maximum of 32 elements. Variation in the concentration of ionic nonionic and carbonaceous aerosols is not related with wind pattern and its velocity.

Key words: Organic carbon, Elemental Carbon, Carbonaceous aerosols, Ionic components and Non ionic components

1. Introduction

Particulate air pollution is a mixture of solid, liquid or solid and liquid particles suspended in the air. These suspended particles vary in size, composition and their origin. Air borne particulate matter represents a complex mixture of organic and inorganic substances. Particulate matters are mostly generated by human activities and also in some cases by natural process. They enter the atmosphere from dust on the road surface which is entrained by the motion of the vehicle along the road. It may come originally from deposited atmospheric dusts, materials carried onto the road by vehicles or erosion or the wear of the road surface itself. The sources, characteristics and potential health effects of total suspended particles (TSP) and particles with aerodynamic diameter less than 10µm (PM_{10}) are very different. Carbonaceous aerosols, organic carbon (OC) and elemental carbon (EC), constitute a major fraction of particulate matters. EC and OC occupy very important fraction of PM and they account typically 10% to 50% of atmospheric PM mass [1, 2]. The classification methods of carbonaceous aerosol vary with different detection methods [3]. EC is emitted directly by primary combustion sources such as biomass burning [4], vehicular exhaust [5] and coal combustion [6]. OC is a poorly characterized aggregation of thousands of individual compounds from different sources [1]. China is a major emission source of global carbonaceous aerosol due to its high rates of usage of coal and biofuels [7, 8]. Carbonaceous materials contribute a significant fraction in PM of atmosphere. Percentage of these carbonaceous materials in the particulate matters of the atmosphere depends on topography of the observing site and its nature. The ratio of OC and EC differs considerably by source and fuel type [9]. For example, diesel EC emissions are associated with low OC levels, whereas burning of wood or biological waste is associated with a high OC/EC ratio. In Kathmandu valley percentage of BC in PM_{10}lies between 18-56 while in TSP it is between 18-22 [10]. In another report, it is mentioned that Si, Na^+, Fe, NH_4^+, SO_4^{2-}, $Ca^{2+}$and Cl^- are the major contributor of the air borne particulate matter of Kathmandu valley [11].

In the past many report had been presented regarding the variation of particulate matters along with carbonaceous aerosols in Kathmandu Valley but only a few regarding the chemical composition. In the present paper an attempt has been done to identify the chemical composition of particulate matters and soil of Kathmandu Valley to know the possible derivation soil components into air.

2. Methods and Procedure

Particulate matters PM_{10} and TSP were collected on quartz 47 mm filter using Frm OMNI™ Ambient Air Sampler from December 2010 to March 2011 and analyzed. Initial gravimetric analysis was carried out at research laboratory of Engineering Science and Humanities, Central Campus, Pulchowk,Institute of Engineering using digital balance.These samples after levelling were sent to Osaka Prefecture Laboratory, Japan for OC, EC and TC analysis by thermochemical method. Xray fluorescent and ion-chromatoghraphy methods were used for the analysis of elements and ionic components in the same laboratory. Few soil samples taken from nine segments of ring road of the valley were also analysed in the same center to know the constituents of soil and possibilities of their contribution in air samples taken.In addition to this one sample of ash collected from one segment of soil collecting site was also analysed to know its chemical composition and denoted as S_1*in the table (1). The sites are shown in figure 1 (a) and (b).

Kathmandu valley is located between 27 °37'30" N and 27°45'0" N latitude and 85°15' 0" E and 85° 22' 30" E longitude. The base of valley is about 1350 meters above sea level and covers about 340 sq.km.area. Kathmandu valley is surrounded by major mountains in the northern side and consists of three major cities: Kathmandu, Bhaktpur and Lalitpur.

Figure 1(a) Map of Nepal showing Study site

Kathmandu Ring Road

Figure1 (b) Sketch of ring road to show soil samples sites

3. Result and Discussion

Present result and discussion is focused on variation of TSP and PM_{10} in different samples collected and their chemical analysis. Some soil samples taken from the vicinity of the study sites were also analyzed for ionic components and elements to know the contribution of soil in the air sample.

PM_{10} samples shows its variation between (39.5-104.2) µg/m^3 while OC and EC in the same sample varies from (4.8-14.1)and (3.9-10.1) µg/m^3 respectively. TC is the sum of OC and EC so its variation will certainly not different from these components which are from 8.7-24.2 µg/m^3. Figure 1 is showing the variation of PM_{10} in different samples and also variation of OC, EC and TC in it .Variation of each component shows nearly the same pattern when PM_{10} is high OC, EC and TC are also following the same trend because they contribute in the total mass of PM_{10}.

TSP variation in the monitored period is 31.3-84.08 µg/m^3 while OC and EC vary between (5.3-18.2)µg/m^3 and (5.6-10.2) µg/m^3 respectively. Figure 2 is the variation of TSP in different days of sampling and also OC, EC and TC variation in it. Variation of OC, EC and TC in TSP is slightly different from PM_{10} because contribution of these carbonaceous aerosols in TSP is only from10.2-29.2% for OC and 9.8-20.4% for EC while TC varies from 21.6-43.3%.

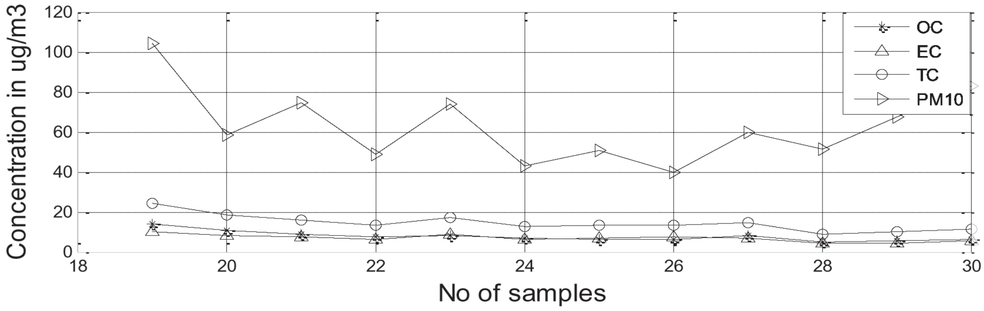

Figure 2 Variation of TC, OC and EC in PM10 samples

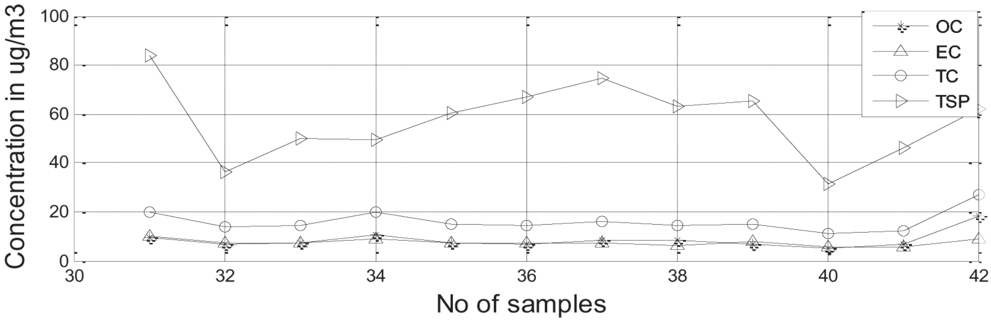

Figure 3 TC, OC and EC variation in TSP samples

3.1 Chemical Composition of Particulate Matters (TSP and PM_{10})

Figure 3 and 4 are box plot and whisker plot for OC, EC, TC, PM_{10} and TSP in different samples of the observed periods. The square sign (▫) denotes mean, the horizontal bar represents median and the hatched boxes contain 25th to 75th percentile range values for the observed period. Outliers are shown as asterisk (*) for the observed period. It is clear that variation of PM_{10} is more than TSP in the study site, while the pattern of OC, EC and TC in both (PM_{10} and TSP) are nearly same.

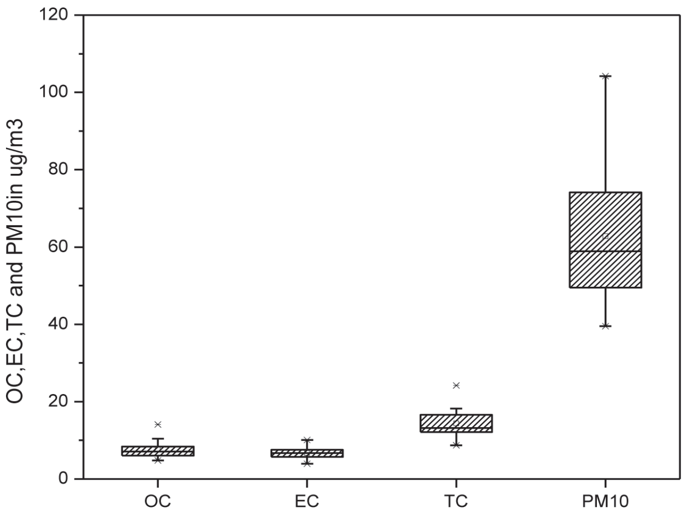

Figure 4 Box plot for variation of OC, EC, TC and PM10 in different samples analyzed

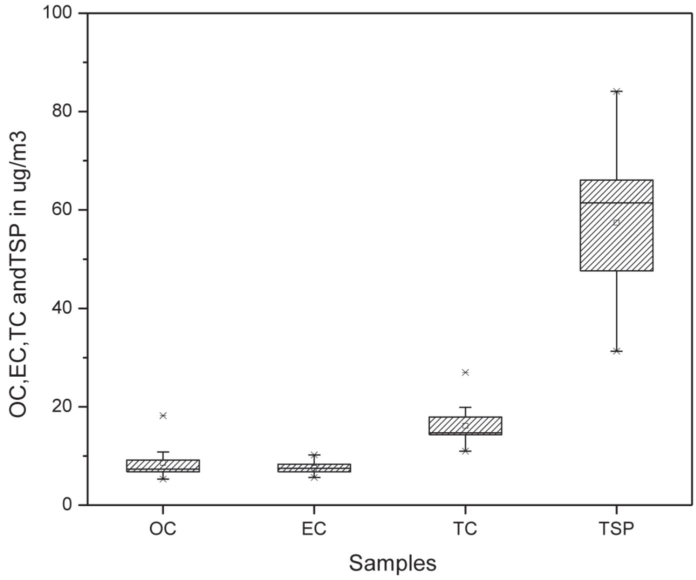

Figure 5 Box plot for the variation OC, EC, TC and TSP in the different samples analyzed

Figure 5 and 6 shows major five elements observed in PM_{10} and TSP samples. In PM_{10} samples common elements were K, Ca, Ti, Fe and Pb which vary from (0.81-1.44),(0.71-1.43), (0.06-014), (0.67-1.55) and(0.00-0.03) $\mu g/m^3$ respectively. The common components in TSP are the same as in PM_{10}.However, their variation in TSP are comparatively more than PM_{10} especially for K, Ca and Fe.

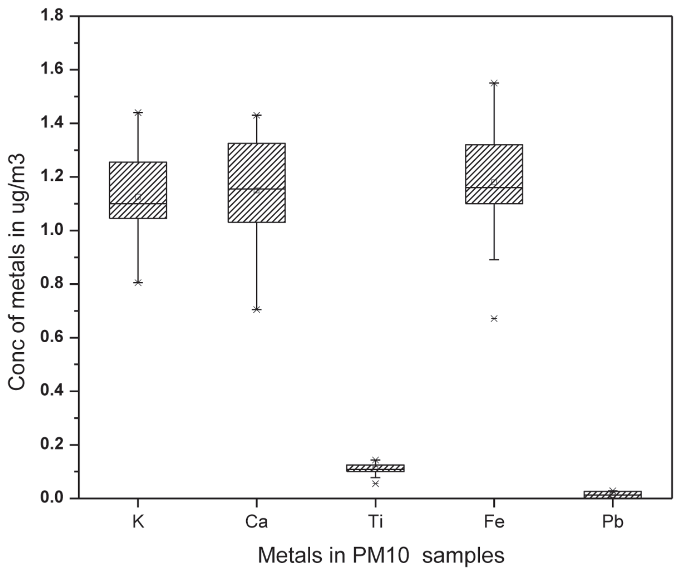

Figure 6 Variation of K, Ca, Ti, Fe and Pb in different samples of PM_{10} represented in Box and whisker plot.

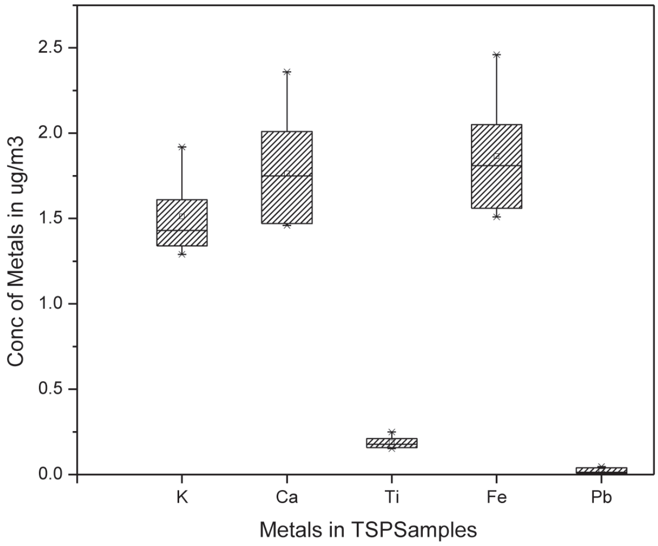

Figure 7. Box and Whisker plot for the variation of K, Ca, Ti, Fe and Pb in TSP samples

To know the components present in the soil of the valley, nine samples of soil from nine different sites Fig 1(b) were taken as K1to K9 samples as in Figure 7 and named as K1 to K9 samples.

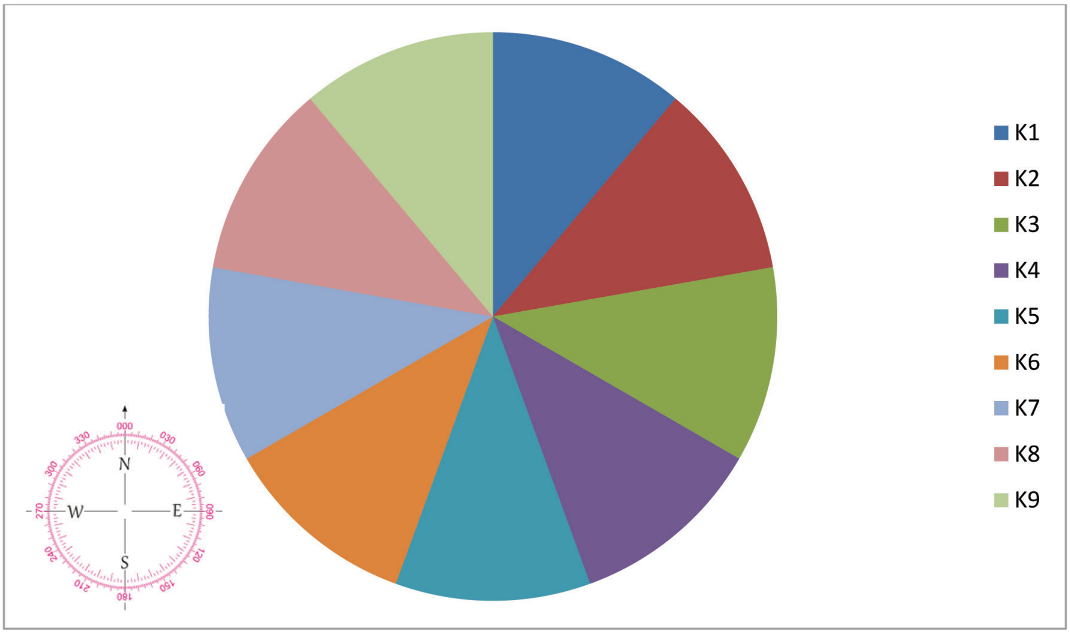

Figure 7. Nine different places of ring road of Kathmandu from where soil samples (Symbolized K1-K9) were taken for chemical analysis

The soil samples collected from K1 to K9 identified a minimum of 26 and a maximum of 32 different elements. The number of elements observed in different sites is shown in figure 8.

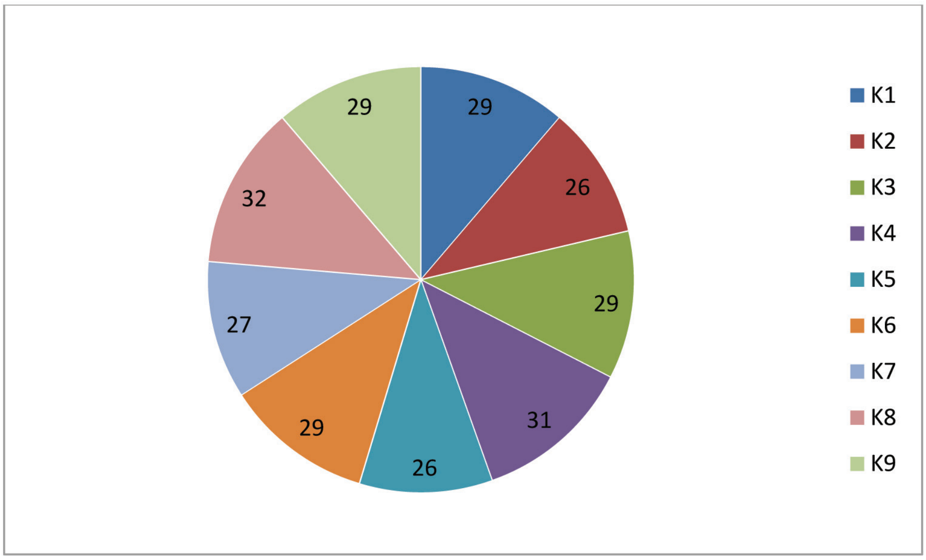

Figure 8. Number of elements identified in nine samples of soil taken from nine different segments of ring road of Kathmandu

Types of elements identified in different samples of soil are presented in the tabular form (sample K1to K9) and elements present in one ash sample (S1*) is also included here (Table 1). Most of the elements are common in all the samples of soil as well as in ash sample. Interestingly elements which are not common in all the samples are Na, Mg, Cl, Br, Ag, and Hg.

Table 1 Different elements present in different samples of soil taken from nine different sites of Kathmandu valley.

Sample K1	Sample K2	Sample K3	Sample K4	Sample K5	Sample K6	Sample K7	Sample K8	Sample K9	Sample S1*
Al	Al	Al	Na	Al	Al	Al	Mg	Al	Al
Si	Si	Si	Al	Si	Si	Si	Al	Si	Si
P	S	P	Si	S	P	S	Si	S	P
S	K	S	P	K	S	K	S	Cl	S
K	Ca	Cl	S	Ca	K	Ca	Cl	K	Cl
Ca	Ti	K	K	Ti	Ca	Ti	K	Ca	K
Ti	V	Ca	Ca	V	Ti	V	Ca	Ti	Ca
V	Cr	Ti	Ti	Cr	V	Cr	Ti	V	Ti
Cr	Mn	V	V	Mn	Cr	Mn	V	Cr	V
Mn	Fe	Cr	Cr	Fe	Mn	Fe	Cr	Mn	Cr
Fe	Ni	Mn	Mn	Ni	Fe	Ni	Mn	Fe	Mn
Ni	Cu	Fe	Fe	Cu	Ni	Cu	Fe	Ni	Fe
Cu	Zn	Ni	Ni	Zn	Cu	Zn	Ni	Cu	Cu
Zn	Ga	Cu	Cu	Ga	Zn	Ga	Cu	Zn	Zn

Ga	As	Zn	Zn	As	Ga	As	Zn	Ga	Ag
As	Rb	Ga	Ga	Rb	As	Rb	Ga	As	Br
Br	Sr	As	As	Sr	Br	Sr	As	Rb	Rb
Rb	Y	Br	Br	Y	Rb	Y	Br	Sr	Sr
Sr	Zr	Rb	Rb	Zr	Sr	Zr	Rb	Y	Y
Y	Nb	Sr	Sr	Nb	Y	Nb	Sr	Zr	Zr
Zr	Ba	Y	Y	Ba	Zr	Sn	Y	Nb	Ba
Nb	La	Zr	Zr	La	Nb	Ba	Zr	Sn	Ce
Ba	Ce	Nb	Nb	Ce	Ba	La	Nb	Cs	Nd
La	Nd	Ba	Ag	Nd	La	Ce	Sn	Ba	Pb
Ce	Pb	La	Ba	Pb	Ce	Nd	Cs	La	Th
Nd	Th	Ce	La	Th	Nd	Pb	Ba	Ce	
Hg		Nd	Ce		Hg	Th	La	Nd	
Pb		Pb	Nd		Pb		Ce	Pb	
Th		Th	Hg		Th		Nd	Th	
			Pb				Hg		
			Th				Pb		
							Th		

4. Conclusion

24 hrs particulate matters samples collected and analyzed showed variation of PM_{10} from 39.5-104.2µg/m^3 where as TSP in the range of 31.3-84.08 µg/m^3 inferring high concentration of discrete particles than large one in the monitored period. Carbonaceous aerosols OC and EC in PM_{10} range from 4.8-14.1µg/m^3 and 3.9-10.1 µg/m^3 respectively. In TSP the same varies from 5.3-18.2 µg/m^3 and 5.6-10.2 µg/m^3. It clearly shows high percentage contribution of OC and EC in TSP than in PM_{10}.OC/EC ratio in PM_{10} and TSP was from 0.9-1.4 in most of the particulate samples. However in one sample of TSP, it was 2.1 indicating the major source of carbonaceous aerosols emission as vehicular emission

Chemical analysis of PM_{10} and TSP samples showed presence of K, Ca, Ti, Fe and Pb as common elements irrespective to their different aerodynamic diameter. It infers their common source of origin. The ionic components identified in the samples were $SO_4^{--}$and NH_4^+ as common ions, where few samples showed presence of Cl^-,NO_3^-, Na^+, K^+, Mg^{++} and Ca^{++} as well. Soil samples analyzed from different segment of ring road showed presence of maximum 32 different elements where K,Ca, Ti,Fe and Pb were common, indicating the source of these elements in the aerosol sample as dust particles driven off from the road dust.

Presence of significant amount carbonaceous aerosols along with SO_4^{--} in the atmosphere is meaningful in the solar radiation budget for their warming and cooling effects.

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