Interactive comment on "Source apportionment and seasonal variation of $PM_{2.5}$ in a Sub-Sahara African city: Nairobi, Kenya" by S. M. Gaita et al.

Responses to Anonymous Referee #1

We would like to thank the Anonymous Referee #1 for the critical and insightful review given to our manuscript.

The responses to his/her specific comments are listed herein;

1. Page 9566, line 24, and further within the manuscript (e.g., page 9567, lines 8-9; page 9567, lines 24-25; page 9568, lines 5-6): References within parentheses within the text should be placed in chronological order.

   Response: References have been ordered chronologically.

2. Page 9571, lines 1-4: How was BC obtained from the reflectometer reading? Some explanation or a literature reference is needed.

   Response: The BC concentration was analyzed using a FH62 1-N black smoke detector (ESM Emberline, Germany). The BC reflectometer utilizes the absorption and reflection properties of the PM loaded on the filter. The amount of reflected red light by the particles is inversely proportional to the amount of the BC present on the sample. The output parameter is normally voltage and the instrument is operated according to black smoke method, which categorizes the blackness of particle layer on a scale of 0 to 9 known as a black smoke number RZ (Gatari & Boman, 2003; Moosmüller et al., 2009).

3. Page 9571, lines 21 and 23: It is not specified what the index "i" indicates. Should it not be "A" instead of "i"?

   Response: The index "i" is supposed to be "A". The correction has been made.

4. Page 9573, lines 9-18: The average data for the $PM_{2.5}$ mass, BC and some elements of the two sites are compared here, but the data for the university site apply to a 2-year period and those for the UNEP site to a period of one year only. One cannot really draw conclusions from this comparison of different periods. It would be fairer to make the comparison for the one-year period that was is common for the two sites.

Response: The authors agree with your observation and have decided to implement your suggestion of comparing the common periods at the university and UNEP sites. Two new tables will be made:

a. Table 1: Summary of the results from all filter samples for the sampling period 22nd May 2008 to 30th March 2010: detection limits, range, mean concentrations (ng m^{-3}), standard deviations (SD) and percentage composition (%$PM_{2.5}$) for detected trace elements, BC and $PM_{2.5}$. N is the number of valid samples.

Elements	Detection limit (ng m^{-3})	Mean (ng m^{-3})	SD (ng m^{-3})	%$PM_{2.5}$	Range (ng m^{-3})	N
S	250	640	340	3.6	250 - 3800	459
Cl	110	480	200	2.7	110 - 1800	723
K	50	310	150	1.7	51 - 840	719
Ca	30	310	250	1.7	30 - 2700	713
Ti	14	54	25	0.3	14 - 180	570
Mn	9.5	41	23	0.2	10 - 190	722
Fe	10	530	350	2.9	11 - 1800	780
Ni	0.8	4	2	0.0	1 - 17	478
Cu	0.7	11	6	0.1	2 - 82	773
Zn	6.6	91	100	0.5	7 - 760	780
Br	2.5	12	21	0.1	3 - 340	667
Rb	0.5	2	1	0.0	1 - 5	383
Pb	1.5	22	18	0.1	2 - 160	525
BC	6	2700	1800	15	74 - 9900	767
$PM_{2.5}$ (µg m^{-3})	1	18	8.6		1.9 - 53	780

b. Table 2. Summary of the results from the University and the UNEP site for the sampling period 16th April 2009 to 30th Mar 2010: range, mean concentrations and standard deviations (SD) for detected trace elements, BC (in ng m^{-3}) and $PM_{2.5}$ (in µg m^{-3}). N is the number of valid samples.

	University			UNEP		
Elements	Range (ng m^{-3})	Mean (SD) (ng m^{-3})	N	Range (ng m^{-3})	Mean (ng m^{-3})	N
S	250 – 1600	660 (240)	132	250 – 1700	620 (280)	184
Cl	110 – 1300	520 (200)	253	110 – 1600	430 (170)	259
K	60 – 840	340 (160)	265	50 – 760	270 (160)	239
Ca	40 – 2700	340 (270)	268	30 – 1300	200 (150)	228
Ti	21 – 180	62 (27)	241	14 – 110	40 (18)	156
Mn	11 – 120	53 (23)	267	10 – 90	28 (14)	236
Fe	33 – 1700	730 (340)	270	11 – 1200	320 (240)	278
Ni	2 – 10	4 (1)	153	1 – 17	4 (2)	191
Cu	2 – 80	12 (7)	269	2 – 55	9 (4)	275
Zn	9 – 760	120 (120)	270	7 – 640	76 (97)	272
Br	3 – 340	16 (30)	240	3 – 70	7 (5)	215
Rb	1 – 5	3 (1)	160	1 – 5	2 (1)	123
Pb	2 – 80	23 (16)	202	2 – 79	17 (14)	186
BC	40 – 9500	3900 (800)	270	70 – 5700	1500 (1000)	267
$PM_{2.5}$ (µg m^{-3})	3 - 53	21 (95)	270	1.9 - 36	13 (7.3)	278

5. Page 9673, lines 22-23: There is an inconsistency here; the percentages of 17 % and 14 % add up to 31 %, which is larger than the 29 % given in line 19.

   Response: BC accounted for 15% and not 17% as indicated. The error has been corrected.

6. Page 9674, lines 2-3, with regard to Fig. 2: It is unclear what the percentage data in the figure denote. Percent of what? Perhaps percent of the sum of the concentrations of the three elements, whereby the BC data were divided by ten? In any case, this should be made clear.

   Response: The authors have reorganized the manuscript and thus felt that the information presented by the said Fig. 2 will be captured and be represented by the new Table 1 and 2 (see comment 4) which will be included in the revised manuscript. Therefore the said figure and corresponding section have been omitted.

7. Page 9575, lines 20-27: The interpretation of the third factor is hard to follow and not convincing at all. The presence of K, Mn, Ni, Cu, Zn, Rb, and BC in this factor do not point to secondary formation processes. This factor looks to me like a mixed factor of biomass burning aerosol (indicated by the presence of K, Zn, Rb) with perhaps some secondary aerosol (part of the S on this factor may be derived from gaseous SO_2 that is emitted by biomass burning).

   Response: After a thorough relook of the third factor, the authors agree with the referee that the factor can be considered to be a mixed factor of secondary aerosol and biomass burning.

8. Page 9577, line 17: It is noteworthy that the Br/Pb ratio of 0.64 in the aerosol is lower than the ratio of 0.77 expected for fresh vehicular exhaust. This could indicate that part of the Br from the leaded gasoline emissions was present in the vapor phase. In their study for the city of Butare, Rwanda, where TEL-B was also used as antiknock agent, Maenhaut and Akilimali (1987) found that the Br/Pb ratio in the aerosol was, on average, 0.68_0.11 (n = 18) during the night versus 0.43_0.03 (n = 16) for the day. The difference was attributed to much more Br being present in the vapor phase during the warm day than during the cool night, and it was stated that this suggests that significant exchange takes place between particulate and gaseous Br. The same is likely also the case for Nairobi.

   Response: The authors agree with the referee's observations and will incorporate the given information in the manuscript.

9. Page 9579, line 3: Although contribution from soil Pb and other anthropogenic sources of Pb may have been partly responsible for the low Br/Pb ratio of 0.43 at the UNEP site, it should not be discounted that part of the automotive Br may have been in the vapor phase, as was discussed in the previous comment.

   Response: The authors are grateful for the referee's input and comments. The said comments will be incorporated into the manuscript.

10. Technical and other minor corrections:

    Response: The highlighted corrections have been worked on.

References

Gatari, M. J., & Boman, J. (2003). Black carbon and total carbon measurements at urban and rural sites in Kenya, East Africa. *Atmospheric Environment, 37*(8), 1149-1154. doi: http://dx.doi.org/10.1016/S1352-2310(02)01001-4

Maenhaut, W., & Akilimali, K. (1987). Study of the atmospheric aerosol composition in equatorial Africa using PIXE as analytical technique. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 22*(1–3), 254-258. doi: http://dx.doi.org/10.1016/0168-583X(87)90338-7

Moosmüller, H., Chakrabarty, R. K., & Arnott, W. P. (2009). Aerosol light absorption and its measurement: A review. *Journal of Quantitative Spectroscopy and Radiative Transfer, 110*(11), 844-878. doi: http://dx.doi.org/10.1016/j.jqsrt.2009.02.035