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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Nepal Ambient Monitoring and Source Testing Experiment (NAMaSTE): Emissions of particulate matter from wood and dung cooking fires, garbage and crop residue burning, brick kilns, and other sources" *by* Thilina Jayarathne et al.

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Referee #1 General Comments: Jayarathne et al. present emissions factors for various particle and gas-phase compounds emitted from combustion sources in Nepal. These sources include brick kilns, garbage burns, generators, water pumps, motorcycles, cooking stoves, and crop fires. These sources have not been well characterized in the past and significantly contribute to the air quality in this region. The study is very

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Discussion paper

detailed and does a great job in comparing their values to previous work. EFs from this study are useful for source apportionment and regional air quality models. This study should be published in ACP after the authors address the below minor comments.

Response to Referee #1 General Comments: We thank the reviewer for their careful review of the manuscript and their suggestions to improve it. We respond to each comment point-by-point below.

Minor Comments:

Referee #1 Comment 1: Page 2, line 26: mobile instead of moveable

Response to Referee #1 Comment 1: The field laboratory used in source characterization is most accurately described as “moveable”, in our opinion, because the laboratory was stationary during sample collection. A mobile laboratory, on the other hand, implies that samples were collected while moving. For this reason and to maintain consistency with our companion paper from NAMaSTE (Stockwell et al., 2016), we prefer to keep this described as a “moveable laboratory.”

Referee #1 Comment 2: Page 3, line 13: whereas the force-draught. . .

Response to Referee #1 Comment 2: Following the reviewer’s suggestion, we think it would be most clear to split this sentence in two, in order to first describe the zig-zag pattern and then the approach to forced-draught, both of which apply to the kiln that were characterized. The revised text reads, “Air moves in a zig-zag pattern through stacks of bricks and is vented through a central smoke stack. The forced-draught style employs a fan to generate air flow.”

Referee #1 Comment 3: Page 3, line 29: change quantity to amount

Response to Referee #1 Comment 3: This change has been made as suggested.

Referee #1 Comment 4: Page 4, line 6: the majority of which were not collected and were ultimately burned. . .

Response to Referee #1 Comment 4: This change has been made as suggested.

Referee #1 Comment 5: Page 4, line 11: The challenges in characterizing

Response to Referee #1 Comment 5: This change has been made as suggested.

Referee #1 Comment 6: Page 5, line 6: should be 1970s

Response to Referee #1 Comment 6: This change has been made as suggested.

Referee #1 Comment 7: Page 5, line 27: I do not think VOC has been defined yet.

Response to Referee #1 Comment 7: We agree with the reviewer and have defined VOC here, which is its first appearance.

Referee #1 Comment 8: Page 6, line 9: the phrase "particularly for women and children who are near to the source" is a bit confusing. Maybe just state that women and children spend more time indoors near the burning source?

Response to Referee #1 Comment 8: We agree with the reviewer's suggestion and have revised the text to read: "particularly for women and children who spend more time indoors near the combustion source."

Referee #1 Comment 9: Page 6, line 21: Please change the sentence starting with "High pollution" so it exhibits parallel structure.

Response to Referee #1 Comment 9: As suggested by the reviewer, we have revised this sentence to exhibit parallel structure. The revised text reads: "High pollution levels in Kathmandu are a consequence of its growing population, rapidly expanding vehicular fleet (Shrestha et al., 2013), unpaved roadways, insufficient electrical power, widespread use of solid fuels for household energy needs (Smith et al., 2013), and common practice of burning garbage (Wiedinmyer et al., 2014)."

Referee #1 Comment 10: Page 6, line 25: "Further, its valley topography traps pollutants, and. . ."

Response to Referee #1 Comment 10: We have added a comma following “pollutants” as suggested.

Referee #1 Comment 11: Page 6, line 27: “ The Tarai. . .” sentence is awkward.

Response to Referee #1 Comment 11: We have revised this sentence to read: “The Tarai, a predominantly agricultural region of southern Nepal, provided access to diesel groundwater pumps, agricultural residue burning, garbage burning, and additional samples of household biofuel combustion.”

Referee #1 Comment 12: Page 7, line 25: 2.5 m length for a sample inlet is quite long. What are the particle and semi-volatile losses for this inlet? Also Teflon coated filter holders may have significant particle losses. Has this been characterized?

Response to Referee #1 Comment 12: The inlet was designed to allow sampling of smoke at a safe distance from combustion sources, and 2.5 m is not considered to be particularly long for combustion smoke sampling. Particle losses in a 2.5 m length if tubing with a 6.35 mm diameter at a flow rate of 7.5 lpm were estimated using the Particle Loss Calculator (PLC) (von der Weiden et al., 2009), allowing for losses due to diffusion, sedimentation, and turbulent inertial deposition. The model assumed unit density and a particle shape factor of 1. The estimated particle losses were less than 1% for particles in the size range of 50 nm – 2.5 microns that encompasses the vast majority of particle mass. Thus, sampling line losses are considered to be minor and are well within the estimated uncertainties. Semi-volatile losses were not considered, as semi-volatile species were neither gas nor particle phase analytes. Loss to the Teflon-coated filter holder was not characterized; however this is expected to be small because the filter holder is made of a non-sticking material and the particles are in contact with the filter holder for a very short time. Further, the filter holder manufacturer is not aware of any particle losses on the surface and expects any particle loss to the filter holder to be negligible (personal communication).

Referee #1 Comment 13: Page 7, line 30: what temperature was the sample at when

it was sampled?

Response to Referee #1 Comment 13: Samples were collected at ambient temperatures (page 7 line 27), which ranged 12.3-28.6 oC in the Kathmandu valley, averaging 18.8 oC. To clarify this point, these temperatures have been added to page 7 line 27.

Referee #1 Comment 14: Page 9, line 12: Can old be better quantified?

Response to Referee #1 Comment 14: We have added the age of each generator at the time of sampling to the method description on page 9. The revised text reads: "Emissions from one petrol (4 kVA, 3 years old) and one diesel (5 kVA, 4 years old) generators were evaluated, using equipment rented in Kathmandu."

Referee #1 Comment 15: Page 9, line 25: burning emissions sampled

Response to Referee #1 Comment 15: We agree with the reviewer and have implemented this change.

Referee #1 Comment 16: Page 10, line 1: Can the authors be a bit more specific about types of plastic? Predominately poly styrene? Or PVC? Or polypropylene?

Response to Referee #1 Comment 16: We have clarified this point by adding "that were predominately made of polyethylene" on page 10 at line 2.

Referee #1 Comment 17: Page 13, line 4: The sentence with "EFs for other particle. . ." is confusing? I could not quickly figure out the equations the authors were getting at.

Response to Referee #1 Comment 17: We have clarified this sentence to read: "EFs for PM components were calculated as the product of EFPM2.5 and the component's mass fraction in PM2.5." With this clarification, we removed the example EFOC calculation from the following line.

Referee #1 Comment 18: Page 14, line 16: The sentence starting as "Another positive aspect. . ." is confusing. How does high concentrations (high concentrations of what? PM?) mean lower amounts of SVOCS? (SVOCs also has not been defined) I would

think SVOCs would also be high concentration if PM is high concentration.

Response to Referee #1 Comment 18: We have clarified this sentence to address the reviewer's questions. The revised text reads: "Also, sampling filters at high PM concentrations provides a better measure of total carbon (including SVOC and PM) since the capability to measure the evaporated SVOC in the gas phase is uncommon."

Referee #1 Comment 19: Page 17, line 11: what does "processed in the same way" entail?

Response to Referee #1 Comment 19: We have clarified this by describing the specific process that we were referring to. The revised text reads: "...with the sum of EF for OC, EC, metals and ions (excluding sulfate), which ranged 0.67-1.33 g kg-1 for the zig-zag kiln."

Referee #1 Comment 20: Page 19, line 9: what does damp mean? How damp? Can this be quantified more than just damp?

Response to Referee #1 Comment 20: While we do not have a specific measure of dampness, we have added discussion of the state of the garbage at page 19 on line 12: "For these samples, garbage had been dampened by rainfall the previous evening, making it difficult to ignite (requiring newspaper) and causing it require re-ignition on occasion (Stockwell et al., 2016)."

Referee #1 Comment 21: Page 19, line 26: Could it also be overestimated? Variability implies over and under estimation.

Response to Referee #1 Comment 21: We agree with the reviewer and have revised this sentence to say "may be either over- or underestimated."

Referee #1 Comment 22: Page 22, line 18: What does Measured organic species include? All those that are resolved in the GCMS? Or those that are positively identified with standards?

Response to Referee #1 Comment 22: In light of this comment, we have clarified this point, by rewording this sentence to begin: “Organic species quantified by GCMS. . .”

Referee #1 Comment 23: Page 22, line 28: What defines steady state operation? The engine reaches a certain temperature? How long did it take to reach steady state?

Response to Referee #1 Comment 23: Collection of gas-phase measurements from agricultural diesel pumps commenced during the cold start-up phase and also encompassed regular continuous operation conditions (Stockwell et al., 2016). Because collection of PM samples did not include the cold start phase, we wanted to make this clear to the reader. In order to align our terminology to our companion paper, we have revised “steady-state operation” to be “continuous operating conditions approximately 8 minutes after a successful start-up”

Referee #1 Comment 24: Page 23, line 4: Why is EFPM2.5 being compared to EFPM1? The authors comment that these values are comparable but they should not as the particle cutoffs are different. There should be less PM1 than PM2.5 by mass.

Response to Referee #1 Comment 24: We agree with the reviewer’s comment. We compared to co-located measurements by Goetz et al. (in preparation) in an attempt to validate our observations. The similarities in EFPM1 and EFPM2.5 suggest that the majority of the PM mass emitted from the groundwater pumps was less than 1 micron. However, since this manuscript remains in preparation at this time, we will remove the reference here and instead compare to the EPA emission factor (AP 42) of 6.0 g kg-1 (EPA, 1996).

Referee #1 Comment 25: Page 25, line 6: Rephrase sentence starting with “The comparison. . .”

Response to Referee #1 Comment 25: As suggested by the reviewer, we have rephrased this sentence. It now begins: “Changes to motorcycle EF before and after. . .”

Referee #1 Comment 26: Page 30, line 23: should be e.g. instead of i.e.

Response to Referee #1 Comment 26: We agree with the reviewer and have applied this correction in the revised manuscript.

Referee #1 Comment 27: Figure 1: Why does this figure not include EC? Section 3.1 also does not include EC. Is there a reason it was not measured for these samples?

Response to Referee #1 Comment 27: EC was below the detection limit for these samples. To clarify this point, we have added the following text to the Figure 1 captions: "EC was not detected in brick kiln emissions; optical measurements of BC from Stockwell et al. (2016) are provided in Table 1."

Referee #1 Comment 28: Figure 2: These colors are difficult to distinguished from each other. Black for EC looks like smushed Metals contributions. The chloride and Nitrate blues look the same. Smushed green for ammonia looks blue-ish too.

Response to Referee #1 Comment 28: We thank the reviewer for pointing this out. To improve the readability of these figures, we replaced the thick black lines in this figure with thin lines, altered the colors to provide more contrast, and widened the bars. We have applied these changes to the other similar figures in the text, to improve their readability as well.

Referee #1 Comment 29: Figure 6: Why are biomarkers reported in different units than EF?

Response to Referee #1 Comment 29: Biomarkers are normalized to the OC concentration, because this accounts for the variation in EFOC (and thus EFbiomarkers) across different burns. To clarify this point, we have added the following text to the figure caption: "Normalization to OC accounts for the large changes in EFOC observed across different combustion scenarios and demonstrates consistency in the molecular marker-to-OC ratios for common fuels."

Works Cited

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