Agricultural air pollution in Indonesia: A mini-review

A F Lu’ayi* and P Lestari
Major of Environmental Engineering, Bandung Institute of Technology, Jalan Ganesha No.10, Bandung 40123, Indonesia

*auliafluayi@gmail.com

Abstract. Indonesia is an agricultural country that is a majority of the population consuming rice, corn and sugar cane for daily energy. But farmers tend to do open burning to their agricultural waste. The open burning practice of agricultural waste is filled with PM2.5 which contributes to air pollution. The research of air pollution modelling in Indonesia often uses the default value of global inventory. This gives the modelling results that are less representative of the situation in Indonesia. Therefore, it is necessary to develop a PM2.5 emission inventory from the agriculture sector in Indonesia. In addition, the inventory of PM2.5 emissions from the agricultural sector in Indonesia is still relatively minimal. In addition, most of research in Indonesia still focuses on agricultural burning activities and has not been able to identify the PM2.5 emissions from the preparation of agricultural land activities. In fact, according to international research, the two largest emissions of PM2.5 on the agricultural sector came from agricultural biomass burning activities and the preparation of agricultural land. Therefore, a comprehensive inventory study need to be investigated immediately in order to determine local factor emission as a better representatives input for agricultural air pollution modelling in Indonesia.

1. Introduction
The atmospheric pollutant of the agricultural sector is a key factor in regional air quality [1]. Thus Indonesia is an agricultural country that is a majority of the population consume rice and corn as a source of carbohydrates, as well as using sugar cane as the main basic ingredient for daily use of sugar. Rice and corn are a source of carbohydrate and sugar containing essential nutrients such as proteins, minerals and various varieties of glucose. The nutrient content is an essential nutrient that is indispensable to the body. Therefore, Indonesia has many people who work as farmers with large agricultural land.

Farmers tend to do open-burning against their agricultural waste. This proved to be an easy, inexpensive and trustworthy move that can handle the accumulation of the remaining agricultural biomass rapidly, and can also be a way of controlling the wild grass and able to restore nutrients to the soil with a short period of time [2]. However, the activity contained toxic air pollutants in large quantities (particulate, organic and inorganic gases) and greenhouse gases [3,4]. The practice of open-burning agricultural waste that increases air pollution is not only happened in Indonesia alone, but also happened in some other areas such as: America, Europe, Taiwan and Thailand [5-8]. Many reports of increased air pollution from agricultural waste-burning activities from various regions showed urgency to do in-depth analysis of these emissions.

The latest research has reported the magnitude of the PM 2.5 and BC emission factors from the burning of agricultural waste in West Java. The results showed the PM 2.5 emission factor from the...
burning of rice straw biomass amounting to 0.55 g/kg and the biomass sugar cane of 0.49 g/kg. However, the study has not analyzed the chemical characteristics of PM 2.5 which closely relates to the toxic properties of the particulate [9].

At a comprehensive inventory conducted in China from the agriculture sector include land preparation, harvesting, biomass residue burning, harvest processing, fertilizer application, and the use of agricultural machinery equipment [1]. Based on research on a wide range of activities from the agricultural sector, the largest emissions resulted from agricultural biomass combustion and the second largest emissions resulted from land-preparation activities (including fertilizer application). Meanwhile, in Indonesia does not have a comprehensive inventory in the agriculture sector. In addition, the determination of comprehensive inventory in accordance with the activities of agricultural sector in Indonesia is important to be done so that the proposed policy recommendation can be prepared in accordance with the phenomenon of local/national problems in Indonesia.

2. Methods
Studies published in Indonesia and several studies globally were identified and reviewed using PubMed, Google/Google Scholar, Science Direct and Web of Science. The eligible studies included those describing emission inventory (EI) from agricultural air pollution, different activities of agricultural sector and different pollution that had been explained.

First, the paper of EI on agricultural air pollution from inside and outside Indonesia were screened, and the paper were selected that showed how lacking of Indonesia’s paper towards this EI agricultural air pollution compared to international/global paper. Second, the papers were selected that showed how the variations in of different activities in agricultural sector and different parameter of pollutant could differ a richness of EI. Third, it has been evaluated how the rich and local EI could be related to the predicted total and regional emission in Indonesia.

3. Results and discussion

3.1. Agricultural EI in Indonesia
Agricultural air pollution globally has been reported tremendously, yet Indonesia still has long way to be pursued. Using the idea of the advance research from another country could give Indonesian researcher a reference of next stepping stone of developing agricultural air pollution research. For understanding clearer development of agricultural air pollution in several countries—including Indonesia—here are the Table1 below.

| Author | Location | Overview |
|--------|----------|----------|
| [1]    | China    | PM10 and PM 2.5 emissions comprehensive inventory as well as gas pollutants (VOCs, SO2, NH3, CO, NOx, and HC) from the agriculture sector. Identifying six agricultural activities: land preparation, harvesting, biomass burning, grain processing, fertilizer application, and agricultural machinery use. |
| [10]   | Thailand | The influence of open combustion of agricultural and forest biomass in Thailand against carbonaceous components (including Char-EC and soot-EC) and particle size fractions. Their seasonal characteristics and behaviors are evaluated based on the Thermal/Optical reflectance method as well as BC using aethalometer. BC and OC are used to investigate the contribution of agricultural activities and forest fires and agro-industries in Thailand. |
| Author | Location | Overview |
|--------|----------|----------|
| [11]   | Indonesia| The chemical speciation PM 2.5 form of water-soluble ionic derived from peat land fires on Sumatra Island (not even an agricultural sector). NH$_4$Cl is a consistently dominant component. The four components, C$_2$O$_4$$^{2-}$, NO$_3^-$, SO$_4^{2-}$, NH$_4^+$, indicate very high levels during the haze period rather than non-haze. These four ions are known as the primary components of an aerosol formed secondary. |
| [12]   | China    | PM2.5 influence on agricultural production in China from 2001-2010. PM2.5 has significant side effects on the average yield of wheat and corn, indicating that the reduction of PM 2.5 can contribute to the outcome of these two plants. Similar to climate factors, such as temperature, rainfall, and sunlight, PM 2.5 has a quadratic effect on average yield of wheat and corn. |
| [13]   | China    | Air pollutant emissions inventory from agricultural machinery equipment in China high resolution. Tractors and agricultural transport vehicles are the two largest contributors with a contribution of 39.9%-53.6% and 17.4%-24.6%, of the total emissions of five pollutants (PM10, PM2.5, NOx, CO and SO2). Agricultural transport vehicles accounted for the most (81.8%) THC emissions. |
| [14]   | China    | Emission characterization, environmental influences, and PM 2.5 emission control from the combustion of the remaining agricultural biomass in China. The chemical compositions in our measurements include elements of carbon (EC) and organic carbon (OC), water-soluble ions (WSI), polycyclic aromatic hydrocarbons (PAHs) and aromatic alkyl-polycyclic hydrocarbon (APAHs). PM 2.5 emissions from the combustion of agricultural residues (rice, wheat, corn) are estimated at 1248 Gg (2003), 1485 Gg (2008), and 1826 Gg (2013). |
| [15]   | China    | PM10 and PM 2.5 Local emission inventory of land-preparation and harvesting activities in Northeast China. |
| [9,16] | Indonesia| Determination of emission factor (EF) & EI from agriculture biomass burning (paddy, maize, and sugar cane) in Indonesia. This study elucidated 2 pollutants which are PM2.5 & BC. |

Based on the Table 1 above, it is clearly that agricultural air pollution research in Indonesia still lacking in a lot of aspects. Over 8 papers above, China is already 62.5% dominated and up ahead with so much advance yet comprehensive research towards this topic. While Indonesia and Thailand right behind China. What makes China is so upfront is that because China already consider a lots of factors related to agricultural sector such as the very different activities of agricultural sector (land preparation, harvesting, biomass burning, grain processing, fertilizer application, and agricultural machinery use), the bunch of pollutants parameters (PM10, PM 2.5, EC, OC, WSI, PAHs, APAHs, NOx, CO, SO2, THC, VOCs), the agricultural commodities (rice, wheat, corn), and seasonal factors. While Indonesia’s research still covers the agricultural biomass burning activities, with pollutants of PM2.5 and BC, and the agricultural commodities which are paddy, maize, and sugar cane, and don’t reach the consideration of seasonal factors. But, Thailand already investigate this seasonal effect for agricultural air pollution. So, in other word, researchers of Indonesia have a very huge chance and option for fulfilling the gap of this agricultural air pollution research. Using a chamber experiment as presented by China’s research also could be chose as one of alternative for more efficient research. The upcoming agricultural air pollution research in Indonesia could be used as a very great foundation and stepping stone for the more advance upcoming research.
3.2. Potency of agricultural air pollution modelling in Indonesia
The research of air pollution modelling in Indonesia often uses the default input source profile globally. This gives the modeling results that are less representative of the situation with local phenomena in Indonesia. Therefore, it is necessary to develop a more advance agricultural air pollution research in Indonesia. The enrichment of EI based on local EF and source profile in Indonesia will give a tremendous possibility for a better agricultural air pollution modelling in Indonesia. Because source profile be used as one of the important inputs in the local receptor model. By using the input source profile of the research is expected to produce more representative model output of agricultural waste burning case in Indonesia. Therefore, the policy recommendation on the burning of agricultural waste in Indonesia can be compiled more responsive.

4. Conclusion
Agricultural air pollution research in Indonesia can be pursued for a better advance with the additional consideration of different activities of agricultural sector (land preparation, harvesting, biomass burning, grain processing, fertilizer application, and agricultural machinery use), the bunch of pollutants parameters (PM10, PM 2.5, EC, OC, WSI, PAHs, AP Ah s, NOx, CO, SO2, THC, VOCs), and seasonal factors. Because Indonesia does not have a comprehensive inventory in the agriculture sector. In addition, the determination of comprehensive inventory in accordance with the activities of agricultural sector in Indonesia is important to be done so that the proposed policy recommendation can be prepared in accordance with the phenomenon of local/national problems in Indonesia. Furthermore, a comprehensive inventory study need to be investigated immediately in order to determine local factor emission as a better representatives input for agricultural air pollution modelling in Indonesia.

References
[1] Li R, Chen W, Xiu A, Zhao H, Zhang X, Zhang S and Tong D Q 2019 A comprehensive inventory of agricultural atmospheric particulate matters (PM 10 and PM 2.5) and gaseous pollutants (VOCs, SO2, NH3, CO, NOx and HC) emissions in China Ecological Indicators 107(March) 105609
[2] Kim Oanh N T, Ly B T, Tipayarom D, Manandhar B R, Prapat P, Simpson C D and Liu L J S 2011 Characterization of particulate matter emission from open burning of rice straw, Journal of Atmospheric Environment 45 493-502
[3] Andrea M O and Merlet P 2001 Emission of trace gases and aerosols from biomass burning Global Biogeochemical cycles 15(4) 955-966
[4] Reid J S, Koppmann R, Eck T F and Eleuterio D P 2005 A review of biomass burning emissions part II: intensive physical properties of biomass burning particles Atmospheric Chemistry and Physics 5 799–825
[5] Jiminez J, Claiborn C, Dhammapala R and Simpson C D 2007 Developing a source fingerprint for burning of wheat and Kentucky bluegrass stubble in Eastern Washington and Northern Idaho Environmental Science and Technology 41(22) 7824-7829
[6] Tipayarom D and Kim Oanh N T 2007 Effects from open rice straw burning emission on air quality in the Bangkok Metropolitan Region Journal of Science Asia 33(3) 339-345
[7] Viana M, López J M, Querol X, Alastuey A, García-Gacio D, Blanco-Heras G, López-Mahía P, Piñeiro-Iglesias M, Sanz M J, Sanz F, Chi X and Maenhaut W 2008 Tracers and impact of open burning of rice straw residues on PM in Eastern Spain Atmospheric Environment 42 1941-1957
[8] Yang H H, Tsai C H, Chao M R, Su Y L and Chien S M 2006 Source identification and size distribution of atmospheric polycyclic aromatic hydrocarbons during rice straw burning period Atmospheric Environment 40 1266-1274
[9] Hafidawati 2019 Pengembangan faktor emisi dan inventarisasi emisi particulate matter 2.5 m (PM2.5) dan black carbon (BC) dari pembakaran limbah pertanian (Studi kasus Provinsi Jawa Barat) Disertasi (Bandung: Institut Teknologi Bandung)
[10] Phairuang W, Suwattiga P, Chetiyanukornkul T, Hongtieab S, Limpaseni W, Ikemori F, Hata M and Furuuchi M 2019 The influence of the open burning of agricultural biomass and forest fires in Thailand on the carbonaceous components in size-fractionated Environmental Pollution 247 238–247

[11] Fujii Y, Setiyo H, Tohno S and Okuda T 2019 Chemical speciation of water-soluble ionic components in PM 2.5 derived from peatland fires in Sumatra Island Atmospheric Pollution Research 10(4) 1260–1266

[12] Zhou L, Chen X and Tian X 2018 The impact of fine particulate matter (PM2.5) on China’s agricultural production from 2001 to 2010 Journal of Cleaner Production 178 133–141

[13] Lang J, Tian J, Zhou Y, Li K, Chen D, Huang Q, Xing X, Zhang Y and Cheng S 2018 A high temporal-spatial resolution air pollutant emission inventory for agricultural machinery in China Journal of Cleaner Production 183 1110–1121

[14] Zhang H, Hu J, Qi Y, Li C, Chen J, Wang X, He J, Wang S, Hao J, Zhang L, Zhang L, Zhang Y, Li R, Wang S and Chai F 2017 Emission characterization, environmental impact, and control measure of PM2.5 emitted from agriculture crop residue burning in China Journal of Cleaner Production 149 629–635

[15] Chen W, Tong D Q, Zhang S, Zhang X and Zhao H 2017 Local PM10 and PM2.5 emission inventories from agricultural tillage and harvest in northeastern China Journal of Environmental Sciences (China) 57 15–23

[16] Hafidawati L P and Sofyan A 2017 Emission Factors of Black Carbon (BC) From Rice Straw Open Burning Specific To District Cianjur, West Java, Indonesia International Journal of Geomate 13(36) 126–130