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MONITORING OF PARTICULATE MATTER 10 MM (PM_{10}) IN AMBIENT AIR BY MEANS OF GENT SAMPLER AS AN ALTERNATIVE TO BETA RAY AUTOMATIC ANALYZER FOR AIR POLLUTION MITIGATION

(Pemantauan Partikulat 10 µm (PM10) di Udara Ambien dengan Menggunakan Gent Sampler sebagai Alternatif dari Beta Ray Automatic Analyzer untuk Mitigasi Polusi Udara)

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ABSTRACT

The monitoring of Particulate Matter 10 Mikron (PM_{10}), as one of the critical parameters of air quality in Indonesia, requires equipment that can monitor the actual concentration for 24-hours continuously. Based on that, the anticipation of mitigation against conditions before an episode of pollution occurred can be carried out especially for areas with a history of forest and land fires. This study aimed to find out the correlation between PM_{10} using Gent sampler and PM_{10} using Beta Ray Analyzer. It is important to anticipate the current condition of local capacity in fulfilling monitoring data in one area lacking of sophisticated automatic monitoring instrument like Beta Ray Analyzer. The study was conducted at Pekanbaru station which belongs to the regional environmental office in Riau Province, during January 2013 to March 2014 covering 52 available data from manual sampling 24-hour weekly period using Gent Sampler. It was found that the PM_{10} concentration ranges from 12.7µg/NM^3-148.6µg/NM^3. The statistical analysis of this preliminary study pertaining the correlation coefficient of the two instruments reading is as high as 0.803. Pearson correlation analysis was employed in drawing the statistical inference. It is of interest to conclude that the gravimetric method of Gent Sampler can be used as an alternative method in monitoring particulate in ambient air.

Kata kunci: Particulate, PM_{10}, Gent Sampler, Beta Ray Analyzer, Beta Ray Analyzer, correlation, Pollutant Standard Index.

ABSTRAK

Pemantauan Partikulat 10 mikron (PM_{10}), sebagai salah satu parameter penting kualitas udara di Indonesia, membutuhkan peralatan yang dapat memantau konsentrasi aktual selama 24 jam terus menerus. Berdasarkan hal tersebut, antisipasi mitigasi terhadap kondisi sebelum episode pencemaran dapat dilakukan terutama untuk daerah dengan sejarah kebakaran hutan dan lahan. Penelitian ini bertujuan untuk mengetahui hubungan antara PM_{10} menggunakan Gent sampler dan PM_{10} menggunakan Beta Ray Analyzer. Antisipasi kondisi kapasitas lokal saat ini menjadi pertimbangan penting, dalam memenuhi data pemantauan di satu daerah yang tidak memiliki instrumen pemantauan otomatis canggih seperti Beta Ray Analyzer. Studi ini dilakukan di stasiun Pekanbaru yang dimiliki oleh kantor lingkungan regional di Provinsi Riau, untuk periode Januari 2013 hingga Maret 2014 yang mencakup 52 data tersedia dari sampling manual periode mingguan 24 jam menggunakan Gent Sampler. Didapatkan hasil konsentrasi PM^{10} berkisar antara 12,7 µg/NM^3-148,6 µg/NM^3. Analisis statistik dari studi awal berupa koefisien korelasi dari dua instrumen sebesar 0,803. Analisis korelasi Pearson digunakan dalam memberikan prediksi statistik. Dapat disimpulkan bahwa metode gravimetri Gent Sampler dapat digunakan sebagai metode alternatif dalam memantau partikulat di udara ambien.

***Keywords**: Partikulat, PM_{10}, Gent Sampler, Beta Ray Analyzer, korelasi, Indeks Standar Pencemar Udara.*

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I. INTRODUCTION

The determination of PM_{10} and $PM_{2.5}$ in ambient air using gent stacked filter unit sampler can be applied as a part of Environmental Quality Index (EQI) [1] as well as Pollutant Standard Index (PSI) [2] and with other various Index [3]. The PSI is a representation that gives an early indication or a rapid conclusion of an environmental condition on the specific area daily. This study was design to comprehend the air quality parameters used for the PSI calculation, by focusing only for one critical parameter, PM_{10}. Ideally, there are 5 parameters for PSI calculation in Indonesia: SO_2, NO_2, PM_{10}, CO and O_3 which represent air quality pollutants from anthropogenic activities. However the PM10 is considered to be a major air pollutants that contributes a large impact on human health [4][5].

Based on the results of the Pollution Standard Index in DKI Jakarta, PM10 is a critical parameter which always dominates the results of air quality assessment in Indonesia [6] especially for area surrounding hot spot from forest or land fires [7]. As for the current conditions in Indonesia, only a few regions have automatic monitoring stations using automatic monitoring analyzers, and for this reason, this study focused on alternative applicable method in a way to accommodate available data gained from air quality testing equipment currently available in the area. On the other hand, this study is trying to find the correlation between PM_{10} parameter measurement by means of Gent Sampler as an alternative method, and that of measurement by means of Beta Ray analyzer, which is considered as a reliable and standardized air quality testing method nowadays [8].

Many related studies of comparison between one instrument with others for monitoring particulate in ambient air [8], however, this study is designed to evaluate the potential use of Gent Sampler. The reason why Gent Sampler was chosen as an alternative to real time Beta Ray analyzer is that the ease of the operation. The sampling design was carried out by P3KLL and PSTNT BATAN Team; the routine sampling has been done by local personnel that has been trained by P3KLL; and the samples then were sent to BATAN for gravimetric analysis and further characterization of the air pollutants for the other separate study purposes. the ultimate objective of this study is actually to anticipate the current condition of local capacity in fulfilling monitoring data, meanwhile sophisticated automatic monitoring device and skill are not in place. That is the reason why Gent Sampler was selected rather than other expensive instrument [8],[9].

II. METHODOLOGY

1. Location

The study was conducted at one air quality monitoring station in the city of Pekanbaru, Riau Province (AQMS-PEF-2) at coordinate 04° 31.052’ N and 101° 26.874” E, address: Jl. Jendral A. Yani Pekanbaru. Location selection is done based on the availability of automatic monitors for PM10 parameters, and that of meet the ambient air quality measurement requirements. In fact PEF 2, so called Pekanbaru Fixed Station 2 [10] which fulfills the SNI 19-7119.6-2005, method for choosing ambient monitoring station [11]. Based on this ideal location and instrument, the study was initiated by installing Gent Sampler and Beta Ray Analyzer as well.

2. Instrument

2.1. Gent Sampler

Gent Staked Filter Unit Sampler (Gent Sampler) is one of the instrument used to sample ambient air to measure the particulate concentration both PM_{10} and a $PM_{2.5}$. The operational technique of Gent Sampler is similar with TEOM [5]. This

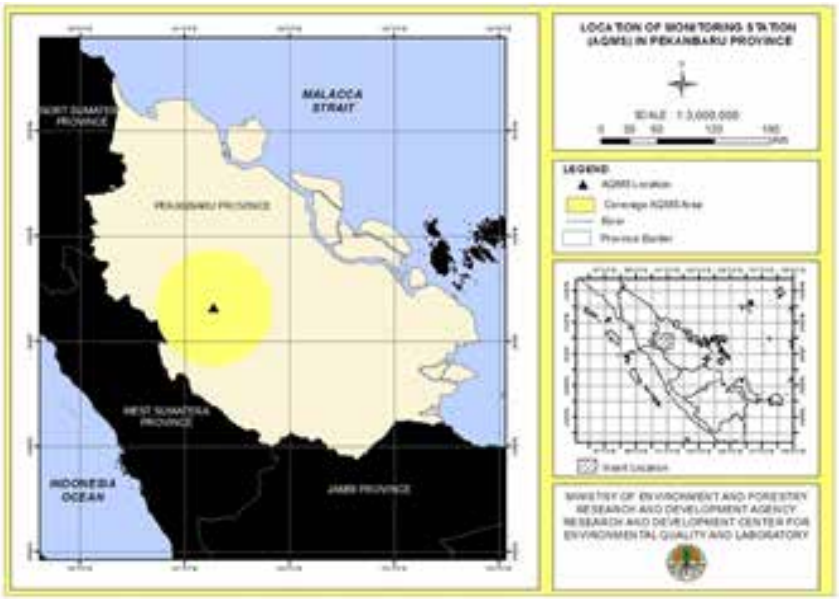

Figure 1. Location of the sampling site

Figure 2. Location of Sukajadi Monitoring Station (PEF2)

Gent Sampler instrument is not widely known in Indonesia. This instrument was first introduced by the National Nuclear Energy Agency (BATAN) to the Center for Environmental Impact Management (PUSARPEDAL) in 2008 in handling lead (Pb) pollution cases in Serpong-Tangerang Selatan-Banten. Through the collaboration of BATAN with Pusarpedal-KLH in terms of air pollution assessment and its impact studies in Indonesia using characterization, source identification, and monitoring of air pollution, these instrument have been gradually installed in 16 government institutions in Indonesia. Sampling activities of the ambient air test using the Gent Sampler were carried out to measure particulates PM_{10} in the study area.

Moreover, Gent Sampler is a dichotomous type of sampling device that can separate particulates from anthropogenic sources from natural sources, and separate coarse particle from fine particles; where both represent anthropogenic activity,

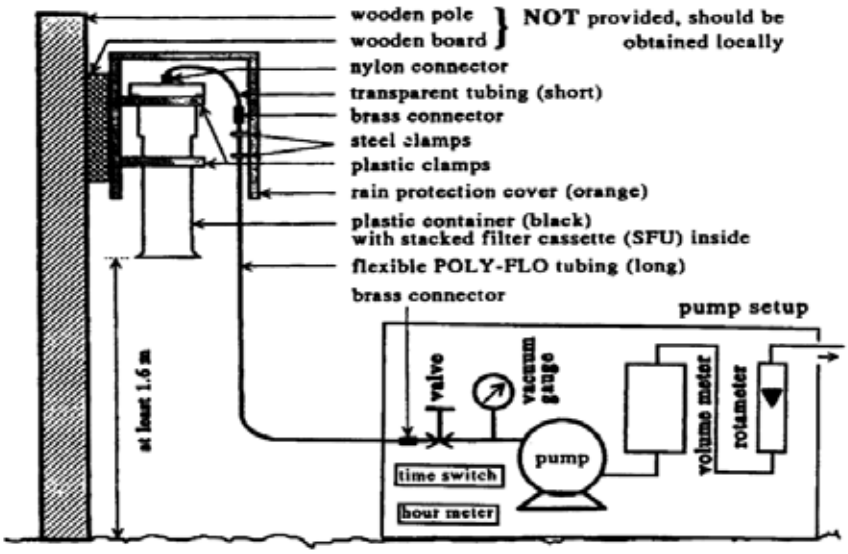

Figure 3. Schematic Diagram of Gent Sampler [13]

with additional information that the fine particulates have more impact on epidemiology [12]–[14]. Gent sampler methods have been implemented for Regional Committee of Air Pollution (RCA) activities in Asia Pacific [12]. The schematic of the Gent Sampler can be seen in Figure 3.

2.2. Beta Ray Analyzer

Beta Ray Analyzer is also known as Beta Attenuation Monitoring 1020 (BAM-1020), an automatic sampling equipment for measuring the PM_{10} of aerosol parameters. Samples were collected hourly through a spot of clean filter tape, and then were treated with a 14C (carbon-14) element that emits a constant source of high-energy electrons (known as beta ray). These beta rays are detected and counted by a sensitive scintillation detector to determine a zero reading. The BAM-1020 then advances this spot of tape to the sample nozzle, where a vacuum pump pulls a measured and controlled amount of outside air through the filter tape, loading it with ambient dust. At the end of the sample hour, this dust spot is placed back between the beta source and the detector, thereby causing an attenuation of the beta ray signal which is used to determine the mass of the particulate matter on the filter tape. This mass is used to calculate the volumetric concentration of particulate matter in ambient air [15].

So far, monitoring of ambient air quality has been done to see a comparison of the fulfillment of ambient air quality standards.

Figure 3. Schematic Diagram of Gent Sampler [13]

There is still a lot of information that can be obtained if air quality is measured with parameters that are more specific and sensitive to changes in environmental conditions, for example the elemental content contained in particles smaller in size than Total Suspended Particulate (TSP), such as PM_{10} and $PM_{2.5}$ [16]. This tool has many advantages, including being able to measure the concentration of real-time dust with a wide concentration range, both small concentrations to high concentrations in the case of forest and land fires. This is not possible for gent samplers. but the disadvantage of this tool is that it requires high competence for operation and maintenance, in addition to the considerable investment costs.

The Annual Performance Report from Dirjen PPKL-KLHK stated that the development of Air Quality Monitoring System (AQMS) network by using automatic monitoring equipment, operated continuously, shall be carried out by the central government, regional governments and the private sector as well as other stakeholders. The parameters monitored are PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3, HC, and CO [17]. The scope of this study is limited to evaluate correlation coefficient in regards PM10 measured by using Gent Sampler and Beta Ray Analyzer.

2.3. Data Analysis

Data analysis was done by using excel, and simple statistical analysis namely linear regression, standard deviation and Pearson correlation.

III. RESULTS AND DISCUSSION

The results of the comparison of PM10 measured by the Gent sampler as compared to PM_{10} with Beta Ray Analyzer at the Pekanbaru station at the same time indicated almost similar pattern except during period of February 19, 2014 to March 13, 2014 (see Figure 5 below). The data displayed is the ambient air sampling for the period of year 2013-2014.

All 52 samples reading are plotted in curve line as seen in Figure 5. In general, it can be shown that there is a relatively a similar trend where there are around 73% of the PM_{10} ratio of Beta Ray Analyzer results to Gent samplers in the range of 0.4-1.4. Ratios smaller than 0.4 there are only less than 6% 5.9%. As for the ratio that is greater than 1.4, it reaches 21.6% which occurs during forest

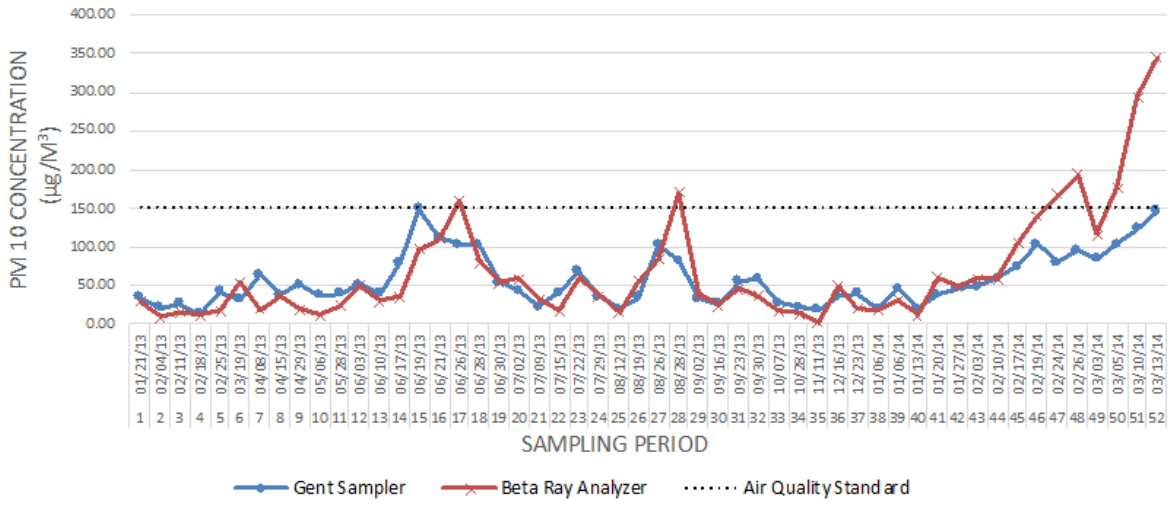

Figure 5. Comparison of PM_{10} Gent Sampler with Beta Ray Analyzer Measurement in Pekanbaru

fires in Pekanbaru and surrounding areas. Furthermore, Figure 5 showed that during a forest fire peak (shaded yellow area), which was around 1 month, namely February 19 to March 13 in 2014. The ratio of the PM10 Beta Ray Analyzer results to the Gent sampler obtained reaches 2.4. As additional information, episode of forest fires start when ambient air quality exceeds 150 micrograms per cubic meter of quality standard [18]. This illustrates that, high difference between two instruments is due to sampling using the Gent sampler are carried out with the same treatment in normal conditions rather than forest fires episode, namely the collection of samples is still done for 24 hours. This is the weakness of this Gent Sampler instrument. The high particulate matter collected during a forest fire causes the filter to clog (clogging) so that the filter must be replaced immediately [13]. For this reason, sampling time should be less than 24 hours depending on particulate concentrations in the event of the forest fire. In this special case, sampling should consider the flow rates reading in the Gent sampler equipment and immediately decide to replace the filters if a blockage is indicated; other possibility is by running the Gent sampler 1 hour ON and one hour OFF [13]. In general, under normal conditions PM_{10} values from the Gent sampler tend to give a value that is relatively the same as Beta Ray Analyzer PM_{10}.

The results of this preliminary study of the correlation of PM_{10} Gent Sampler measurements against PM_{10} Beta Ray Analyzer can be seen in Figure 6.

Positive linear relationship is indicated by the determination coefficient $R^2 = 0.6193$. Based on the value of correlation analysis with Pearson Correlation, the correlation coefficient value is 0.814 which shows the closeness of the correlation value of Beta Ray Analyzer with Gent Sampler with a strong category ($p < 0,01$) [19],[20]. It is implied that Gent Sampler is a reliable instrument compared to Automatic Beta Ray Analyzer. In other Words, this instrument could be applied to measure particulate in local area where is no availability of capacity, both in investment cost and also skills for running complicated Air Quality Monitoring System. Air Pollution Mitigation should be applied properly with this kind of information. Moreover, related to Air Pollution Mitigation, study for early warning system has already been done [21],[22]. Furthermore, detail information could be gained from further analysis of various metals from filter using X-Ray Fluorescence, as it is very useful for

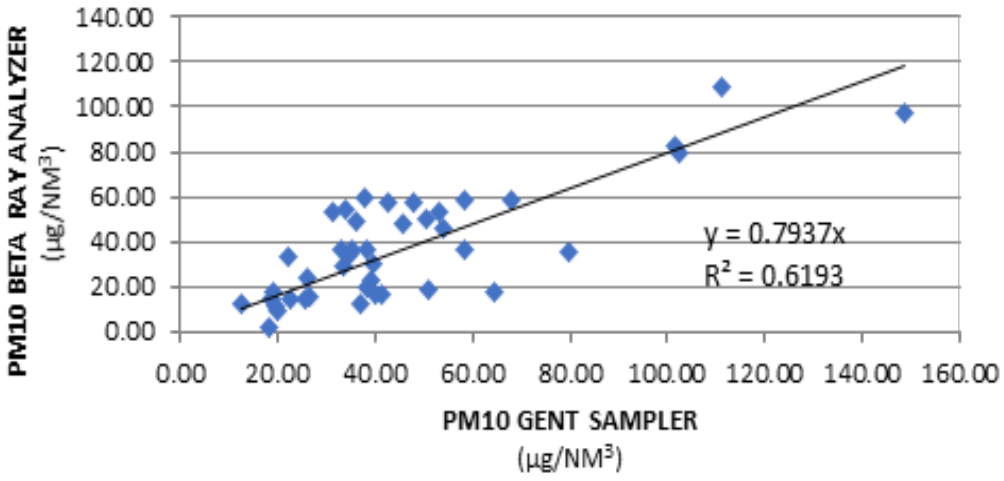

Figure 6. Correlation of PM_{10} sampling result for Gent Sampler and Beta Ray Analyzer

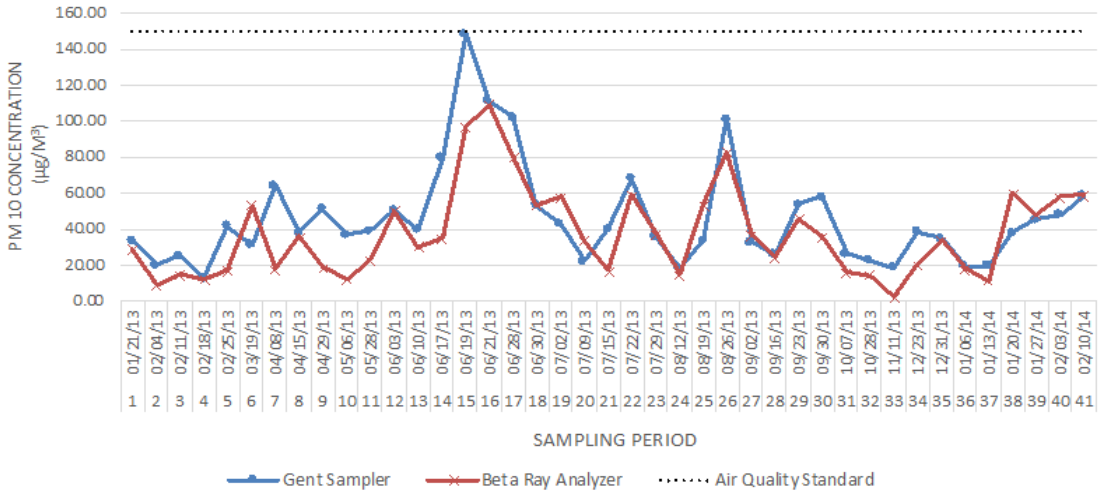

Figure 7. Comparison of PM_{10} Gent Sampler Results with Beta Ray Analyzer Measurement in Pekanbaru (after data cut-off)

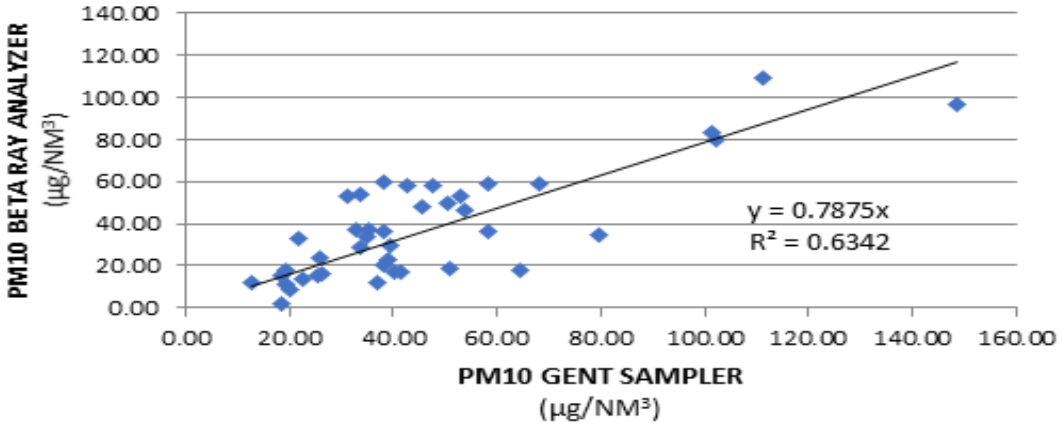

Figure 8. Correlation of PM_{10} sampling result for Gent Sampler and Beta Ray Analyzer (After Data Cut-Off)

environmental forensics [12],[21]–[23].

Figure 7 below shows the comparison between two instruments after 11 data cut-offs was carried out during forest fire conditions, to emphasize the strength of the correlation between two instruments.

In general, it can be shown that there is also a good trend where there are around 71% of the PM_{10} ratio of Beta Ray Analyzer results to Gent samplers in the range of 0.4-1.5. Ratios smaller than 0.4 are 19%. As for the ratio that is greater than 1.5, it reaches only 10% after data cut-off with 41 remaining data. Another source of variabilities, is that the starting point for calculating an average of 24 hours sampling is not the same between Gent Sampler and Beta Ray Analyzer. This could be an improvement for the next study.

Positive linear relationship is indicated by the determination coefficient $R^2 = 0.6342$. Based on the value of correlation analysis with Pearson Correlation, the correlation coefficient value is 0.803 which still shows the closeness of the correlation value of Beta Ray Analyzer with Gent Sampler with a strong category ($p < 0,01$) [19],[20]. It is implied that Gent Sampler is a reliable instrument compared to Automatic Beta Ray Analyzer. In other Words, this instrument could be applied to measure particulate

in local area where is no availability of capacity, both in investment cost and also skills for running complicated Air Quality Monitoring System. Air Pollution Mitigation should be applied properly with this kind of information. Moreover, related to Air Pollution Mitigation, study for early warning system has already been done [21],[22]. Furthermore, detail information could be gained from further analysis of various metals from filter using X Ray Fluorescence, as it is very useful for environmental forensics [12],[21]–[23].

IV. CONCLUSION

The results of the correlation measurement between PM_{10} Gent sampler and PM_{10} Beta Ray Analyzer is a positive linear relationship indicated by the determination coefficient $R^2 = 0.6342$. The statistical analysis of this preliminary study pertaining the correlation coefficient of the two instruments reading is as high as 0.803. It is of interest to conclude that the gravimetric method of Gent Sampler can be used as an alternative method in monitoring particulate in ambient air, especially for area with lack of resources i.e. instrument budgeting and lack of high skill for sophisticated equipment.

As a recommendation, synergy in monitoring can be carried out nationwide which has begun in this study, to improve the quality and quantity of environmental quality research in order to support national environmental development programs. Prioritizing the calculation of PSI limited to particulate parameters $PM_{10}/PM_{2.5}$ for conditions where source availability is limited in the area. For regions that do not have a Beta Ray Analyzer instrument, they can use alternative methods that have a correlation and/or standardization of the reference method or standard.

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DISCLAIMER

The statements and conclusions in this paper are those of the authors and not necessarily those of the brand of Beta Ray Analyzer and Gent Sampler. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

REFERENCES

1. Rita, Lestiani, D. D., Hamonangan, E., Santoso, M. & Yulinawati, H. 2016 Ecolab 10, pp 1–7
2. Kementerian Lingkungan Hidup. (1997).
3. Mukhtar, R., Aprishanty, R. & Fauzi, R. 2018 J. Ecolab 12, pp 32–41
4. Fadhillah, F. 2018 Indones. Cent. Environ. Law
5. [5] Allen, G. et al. 1997 J. Air Waste Manag. Assoc. 47, pp 682–689
6. Dirjen PPKL (KLHK). 20-07-2019 08:00:00 Available at: http://iku.menlhk.go.id/.
7. Winardi, Program Studi Teknik Lingkungan, W. T. P. 2014
8. Chung, A. et al. 2001 J. Air Waste Manag. Assoc. 51, pp 109–120
9. Zheng, T. et al. 2018 pp 4823–4846
10. BLH, L. U. K. P. 2018
11. Badan Standardisasi Nasional. 2003
12. Parr, R. M., Stone, S. F. & Zeisler, R. 1996 Int. At. Energy Agency Bull. 38, pp 16–21
13. Hopke, P. K., Xie, Y., & Cohen, D. 1997 Aerosol Sci. Technol.
14. Seneviratne, S. et al. 2017 Aerosol Air Qual. Res. 17, pp 476–484
15. Monitor, C. P. pp 10–13

16. Kong, S. et al. 2014 Aerosol Air Qual. Res. 14, pp 2017–2028
17. KLHK, P. D. I. (2018).
18. Kementerian Lingkungan Hidup. (1999). pp 1–34
19. Pu, H., Luo, K., Wang, P., Wang, S. & Kang, S. 2017 Environ. Sci. Pollut. Res. 24, pp 4457–4468
20. Sudibyo, H., Shabrina, Z. L., Halim, L. & Budhijanto, W. 2017 Energy Procedia 105, pp 256–262
21. Santoso, M. 2014 Ecolab 9,
22. Santoso, M. et al. 2011 Atmos. Pollut. Res. 2, pp 190–196
23. Kim Oanh, N. T., Pongkiatkul, P., Upadhyay, N. & Hopke, P. P. 2009 Atmos. Environ. 43, pp 3334–3344