Design and built simple air sampling device for NO₂, SO₂, and NH₃ from air ambient

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Abstract

The increasing of human care to common air contamination caused the demanding of air analyzing and air sampling devices increasingly. The purpose of this research is to make simple air sampling device which are easy-handle and cheap. The stability of flow rate is the important element in this assembly-device and to achieve that condition we could be used flow meter. The basic principle of taking air sample using this device is by collecting contaminated air sample to trapped-solution in the impinger-tube. Gas contaminant on the bubble-air will be react with the reagent in the trapped-solution. Furthermore, the trapped-solution with contaminant inside is analyzed with instrumental analyze method using spectrophotometer. The device is using three impingers to place NO₂, SO₂, and NH₃. Nitrogen dioxide is analyzed using Griezz Saltzman method, which the formed azo compound measured at λ 525 nm. Sulphur dioxide is analyzed using Pararosaniline method, which the formed complex is measured at λ 555 nm. Ammonia is analyzed using Nesller method, and its measured at λ 400 nm. From the test of this device compared with Lamotte® we acquired the difference concentration of pollutant-sample aren’t much different.

Keywords: Air sampling device, impinger, trapped-solution, flow rate

Introduction

The impact of present air pollution are the serious problem which faced by so many country included Indonesia. The effects of this air pollution were very harmful. These pollution not only harmful for human health but also it could be damage other component, such as animals, plants, buildings, etc. So that Indonesian people more aware about the risk of air pollution today.

The increasing of human care to common air pollution caused the demanding of air analyzing and air sampling devices increasingly. But, the price of common air analyzing and air sampling devices is expensive so that it’s difficult to get those devices. Furthermore, the important thing is about the success of analyzing air contaminant depends on the success of air sampling technique. An error in technique of sampling air contaminant will be making a worse to the next step of analyzing contaminant. Then, it is need to develop the air sampling device which is simple, easy-handle, and cheap (Agustini et.al., 2005)

The purpose of this research is to make air sampling device for gas NO₂, SO₂, and NH₃ from air ambient which is simple, easy-handle, and cheap. Furthermore, the device has the reliability and the validity which is almost same with the commercial’s air sampling devices.

Materials and Methods

Apparatus

Figure 1 (a) shows a diagram of simple air sampling device for gas NO₂, SO₂, and NH₃. This device is consist of three main component which are pump-suction, impinger-tube, flow measurement, and the others components to support this device.

Suction-Pump

The function of this tool is as an instrument to absorb sample contaminant from air ambient and then bubbled it’s to trapped-solution in impinger tube. In this research we used DC air pump-aquarium as a suction-pump. The system of this suction pump is vibration-valve system (Figure 1 (b)), and used 2 x 1.5 volt of dry-cell battery as a power supply.

Impinger Tube

This tube is used to place a solution-trapped which will absorb contaminant gas. This tube is made from Pyrex glass with the height ± 150mm and can be take in solution up to 50 ml (included allocation for bumping bubble). In the bottom of this pipe-tube, there is a filter which its function is to break the bubble. According to Agustini, et.al (2005) the
reaction become better as the size of formed-bubble smaller because the surface of gas contaminant become wider.

![Figure 1 (a) The Diagram of simple air sampling device. The blue-color doesn’t mean that the real color of solution is blue. (b) Pump (inside the box). Unit measurement: mm](image)

**Flow Measurer**

In sampling of pollutants in air ambient the fluctuations in the flow rate have a significant effect on measurement accuracy when air is sampled. In order to achieve accuracy of measurement volume of air ambient this trapped to solution, it’s necessary to choose a device which can give real information about the flow rate through the whole of air sampling device and to take this rule, there are some tool can be used for this function which are

**Supporting Tool**

**Assembly box**

It is square-box made from wood with the dimensional length about 350 mm, width about 340 mm, and height about 300 mm. All of the components above are placed inside this box (except Orifice meter). In order to make easier the mobility of the device, the assembly box was built with the handle in right and left side of this box. So, it is easier to move this box from one place to another place.

**Materials**

**Sampling and analysis for NO$_2$**

The method for sampling and analyzing of NO$_2$ based on Griezz Saltzman method which NO$_2$ from air ambient will be absorb by Griezz Saltzman solution. The Saltzman method is based on a specific reaction of nitrite ion with diazotizing-coupling reagents to form a deeply colored azo dye. The analysis of samples requires a spectrophotometer. Saltzman method can be sufficiently reliable for sampling periods of up to 2 hours (depends on amount of samples in air ambient). In order to get 95% efficiency of absorption, sampling held in flow rate 0.4 L.min$^{-1}$. If strong oxidizing or reducing agents are present in the air in concentration exceeding that of NO$_2$, measurement of the intensity of coloration should be made as soon as possible to minimize errors due to decomposition of the azo dye. This method can be calibrated statically by using sodium nitrite (NaNO$_2$) standards.

All reagents used in this method should be prepared well. The water used in this method has to in nitrite-free condition. Absorbing reagent is made by dissolve 5 g of sulfanilic acid in approximately 800 ml of water. To speed up the process, the mixture should be stirred mechanically, add 140 ml of glacial acetic acid and 20 ml of the 0.1% stock solution of N-(1-Naphthyl)-ethylenediamine dihydrochloride, and dilute to 1 liter. Avoid lengthy contact with air during preparation and use, since this will result in discoloration of the reagent because of absorption of NO$_2$. This reagent can be stored in a refrigerator for up to 2 months. The standard solution can be prepared by dissolve sodium nitrate in to water. The intensity of the formed color is measured at wavelength 525nm.

**Sampling and analysis for SO$_2$**

The method for sampling and analyzing of SO$_2$ used Pararosaniline method. The Pararosaniline method is based on the absorption of SO$_2$ from the air ambient in a solution of potassium tetrachloromercurate. In this procedure, a dichlorosulfitomercurate complex is formed. The complex is made to react with pararosaniline and formaldehyde to form the intensely colored pararosaniline methyl sulfonic acid. The intensity of the color produced is measured by means of a spectrophotometer and is related directly to the amount of SO$_2$ present in corresponding air sample by means of a calibration curve. Taking sample of SO$_2$ using this method, the sampling flow rate should be held in 0.6 L.min$^{-1}$ and sampling can be held along 30 minutes or 60 minutes.

Absorbing solution (0.04M potassium tetrachloromercurate, TCM) made by dissolve 10.86 g mercuric chloride, and 6.0 g potassium chloride in water and make up to 1000 ml in a volumetric flask.
The absorbing reagent is normally stable for 6 months. And also prepared the supported reagents: sulfamic acid (0.6%); formaldehyde (0.2%); iodine solution (0.01 N); Sodium thiosulfate titrant (0.01 N); standardized sulfite solution; working sulfite-TCM solution; Pararosaniline reagent. The intensity of the formed color is measured at wavelength 550nm.

**Sampling and analysis for NH\textsubscript{3}**

The method for sampling and analyzing of NH\textsubscript{3} used Nessler method. Ammonia will be reacted to form colloid which its color is brown. Ammonia-nessler measured using spectrophotometer at wavelength 400 nm. Nessler’s reagent is prepared by dissolving 70 g of potassium iodide in about 75 ml of deionized water. A saturated solution of mercuric chloride (HgCl\textsubscript{2}) is added until a slight turbidity persists. Then added 160 g sodium hydroxide in 150 ml deionized water carefully and the solution is made up to 1 liter, and allowed to stand overnight in a dark place.

**Experimental design**

In this research, a comparison between assembly-device and commercial device (Lamotte\textsuperscript{®}) was carried out in sampling air ambient for gas NO\textsubscript{2}, SO\textsubscript{2}, and NH\textsubscript{3} at Supratman St. (Gasibu court). The assembly-device and Lamotte\textsuperscript{®} air sampling device were carried out in the same place and time. We made assumption that both of them take a same condition during taking pollutant from air ambient (flow rate, temperature, pressure, height, position, etc.). The next step was both of assembly-device and Lamotte\textsuperscript{®} air sampling

**Results and Discussion**

**Suction-pump**

In this research, we use an air aquarium pump with a modification in the part of that aquarium pump. The test of these pumps show that a single air aquarium pump can carried out the flow rate up to 0.8 L.min\textsuperscript{-1}. Sometimes in sampling air ambient need a flow rate more than 1.0 L.min\textsuperscript{-1}, for example to sampling NH\textsubscript{3} from air ambient (SNI, 2005). To solve this problem, in this research we use two pumps together (we called this double-pump). The result of testing this double-pump show that it can carried out the flow rate up to 1.5 L.min\textsuperscript{-1}.

**Orifice meter**

In this research, we used Orifice meter as a flow meter, the consideration of choosing Orifice meter is because it’s a simple device and an inexpensive one but the accuracy is fair enough. This Orifice meter is based on differential pressure according to Bernoulli’s principle. Furthermore, the basic operating principle of this Orifice meter is based on the knowledge that the pressure drop across the meter is proportional to the square of the flow rate. In order to use this device for measurement it is necessary to empirically calibrate them. That is, pass a known volume through the meter and note the reading in order to provide a standard for measuring other quantities. In this research, the Orifice meter can measure the flow rate until 1.5 L.min\textsuperscript{-1} and the precision of this Orifice is ±0.1L.min\textsuperscript{-1}. So, this Orifice can be used as a flow measurement in sampling of NO\textsubscript{2}, SO\textsubscript{2}, and NH\textsubscript{3} from air ambient since to measure those parameter need a flow rate until 1.5 L.min\textsuperscript{-1} (SNI, 2005).

**Comparison assembly device with Lamotte\textsuperscript{®} air sampling device**

A comparison between assembly device and Lamotte\textsuperscript{®} air sampling device (figure 2) was carried out in Gasibu court, Bandung-West Java. And the result showed that there wasn’t any significant difference of the determining pollutants sample which is NO\textsubscript{2}, SO\textsubscript{2}, and NH\textsubscript{3} from air ambient (Table 1). Sampling for each parameter was carried out three times at the same day. And both of these device (Assembly device and Lamotte\textsuperscript{®}) were carried out sampling pollutant at the same spot at the same time. We made assumption that the condition of these two device are same.

**Figure 2 Lamotte\textsuperscript{®} Air Sampling Device**

**Conclusions**

This assembly device is very useful for taking pollutants sample from air ambient especially for NO\textsubscript{2}, SO\textsubscript{2}, and NH\textsubscript{3}. The Comparison with the commercial device-Lamotte Air Sampling Device-shows that there isn’t any significant difference of the result. The cost that have to be prepared to make this this device is almost cheap. Thus this assembly device can be recommended as a local content for sampling NO\textsubscript{2}, SO\textsubscript{2}, and NH\textsubscript{3} from air ambient.
Table 1 Comparison between assembly device and Lamotte® Air Sampling Device carried out sampling of (a) nitrogen dioxide (NO$_2$), (b) sulphur dioxide (SO$_2$), and (c) ammonia (NH$_3$) at Gasibu Court, Bandung-Indonesia.

<table>
<thead>
<tr>
<th>Device</th>
<th>NO$_2$ Absorbance</th>
<th>NO$_2$ Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamotte®</td>
<td>0.059</td>
<td>0.076 ppm ±0.0127</td>
</tr>
<tr>
<td>Assembly device</td>
<td>0.068</td>
<td>0.086 ppm ±0.0130</td>
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</tbody>
</table>

(a)

<table>
<thead>
<tr>
<th>Device</th>
<th>SO$_2$ Absorbance</th>
<th>SO$_2$ Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamotte®</td>
<td>1.498</td>
<td>1.427 ppm ±0.0253</td>
</tr>
<tr>
<td>Assembly device</td>
<td>1.510</td>
<td>1.416 ppm ±0.0252</td>
</tr>
</tbody>
</table>

(b)

<table>
<thead>
<tr>
<th>Device</th>
<th>NH$_3$ Absorbance</th>
<th>NH$_3$ Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamotte®</td>
<td>0.440</td>
<td>1.023 ppm ±0.177</td>
</tr>
<tr>
<td>Assembly device</td>
<td>0.412</td>
<td>1.098 ppm ±0.181</td>
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</tbody>
</table>

(c)

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References
