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The utilization openCV to measure the ammonia and color concentration in the water

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Abstract. Intensive water quality determination needs to be adjusted with technological developments to meet today's society's needs and increased water pollution due to urbanization. Therefore, early detection is essential for in site water quality determination and as a critical consideration in making health and environmental decisions. OpenCV is a library programming feature for Computer Vision which focuses on extracting information from images in real-time, this can be considered to be potential to measure the pollutant concentration. **Objectives:** This study identify the potential of colorimetry analysis method by using OpenCV as an alternative method for color and ammonia measurement. **Method and results:** First stage, this study collecting the data of NH_3 phenate and Pt-Co CU from the spectrophotometer. The first stage also was including the development of an OpenCV code. Then, the data was collected were processed to get the concentration of NH_3 and Pt-Co both using OpenCV and spectrophotometer; factors that influence the Pt-Co sample image measurement process by using OpenCV-Python was analyzed too. Then in the analysis stage, the result of the two measurement method was tested by statistic determine its significant difference. The conclusion found whether OpenCV could be potential to measure the pollutant concentration or not. **Conclusion:** the OpenCV has potential to be use as alternative colorimetry measurement method to determine ammonia and color in the water as there is no significant difference in the spectrophotometric method results and the results from OpenCV. Result of color by Open CV is from 13.3 to 55 ppm, and result of ammonia is Further research is needed to test the validity of OpenCV method, In this study found that the result of NH_3 from spectrophotometer is nonlinear different with from OpenCV that is linear. The factor influence of measurement using OpenCV code is when determining the Region of Interest

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	(ROI) and determining the pixel values for the normalized box filter.

1 Introduction

Intensive water quality determination needs to be adjusted with technological developments to meet today's society's needs and increased water pollution due to urbanization. Therefore, early detection is essential for in site water quality determination and as a critical consideration in making health and environmental decisions [1][2].

Water quality is calculated referring to the water quality standard that is determined in its utilization [3] According to the Minister of Health of the Republic of Indonesia Regulation Number 32 the Year 2017 concerning environmental health quality standards and water health requirements, several physical, chemical, and biological parameters have been regulated that must comply. So that water is meet with health requirements that safe for human needs. Some of the parameters are turbidity, color, dissolved solids, temperature, odor, total coliform, ammonia, nitrite, and nitrate [4].

Colorimetry is a quantitative analysis used to determine the composition of pollutants using color differences between contaminants in water and the standards [5]. Colorimetry is an example of a spectroscopic analytical approach that absorbs visible light from a sample. The UV-Vis spectrophotometer is a commonly used spectroscopic instrument. The UV-Vis spectrophotometer is absorption-based to detect light absorption through specific wavelengths of light from a homogeneous sample substance [6]. Several previous studies have demonstrated that the process of colorimetry methods is reliable for detecting a variety of parameters using a spectrometric instrument [7][8][9][10]. However, the colorimetry method passed through long steps and equipped with laboratories setting that makes it costly and time-consuming [1].

Digital image processing must be considered as a colorimetry analysis alternative approach to analyzing the quality of water that is relatively cheap[2]. Digital image processing involves transforming physical images to appropriate digital images and generating important information from digital images using numerous computer

programming algorithms[11]. The digital image processing consists primarily of image acquisition, image processing and image analysis. Compression and coding of information is another component of image processing[12]. Several studies proven the used of digital imagery for their differential study, including Pt-Co CU measurement by using ImageJ[13], Nitrite and pH analysis in water samples[14], and build a single computing machine board to analyze colorimetric samples automatically[15]. However, there is still space to improve colorimetric digital techniques, as one approach is typically built explicitly for one analyte [13]

OpenCV is a library programming feature for Computer Vision which focuses on extracting information from images in real-time. Computer vision is the field of electrical engineering, mathematics and computer technology that collects, processes and emulates the eye. Besides, OpenCV also consist of comprehension of real-world photographs and video[16][17] The image information is stored in the color of the frame and is achieved with the number of color pixels taken into account. The color space portrays a mathematical representation of image colors in order to decide the numeric color to be used for mathematical and logical tasks. There are 150 colors of space transformation function in OpenCV that use their characteristics in different applications. The HSV color space is an almost independent light variation of the difference or contrast of the colours, which is often used[17]. HSV color space is therefore in line with colorimetric analysis that measures the contaminant using the color difference of the compound [5].

The objective of this study to identify the potential of colorimetry analysis method by using OpenCV as for color and ammonia measurement. The OpenCV code hopes to be an inexpensive, accurate, and fast processing colorimetry analysis method that enables the determination of pollutant concentration. Previous study proven that OpenCV can be implemented in various field, commonly for real-time face recognition, for automated attendance system[18][19][20]

This paper will examine the development of the openCV code for measuring NH_3 parameter with reference to the Phenate Standard Method based on SNI 06-

6989.30-2005 and color parameter by referring to the Standard Method (APHA, 2005). This study is currently at the preliminary stage, focusing on the constructing the algorithm of openCV code , and factors which affect the results in terms of linearity, background conditions during image collection, factors that influence the Pt-Co sample image measurement process by using OpenCV-Python, which then will be taken into account in further research progress. In processing the data, the OpenCV code will focus on HSV color space coordinates calculation in sample images, where HSV color space values are used to calculate the sample concentrations. The HSV value and absorbance values are then converted from the same sample to concentration values by using the linear equation results from the linear regression test. The results of both measures will statistically checked to assess the significant difference.

2 Method

2.1 Research Framework

As presented in Fig. 1, this research has been carried out in five stages. The first stage was the preparation stage, which includes collecting the data from the spectrophotometer. The first stage also was including the development of an OpenCV code. The second stage was data processing. In this stage, the data was collected were processed to get the concentration of NH_3 and Pt-Co both using OpenCV and spectrophotometer; factors that influence the Pt-Co sample image measurement process by using OpenCV-Python was analyzed too. Then in the analysis stage, the result of the two measurement method was tested by statistic determine its significant difference. In the end, the conclusion found whether OpenCV could be potential to be used as an alternative colorimetric analysis method to measure the pollutant concentration or not.

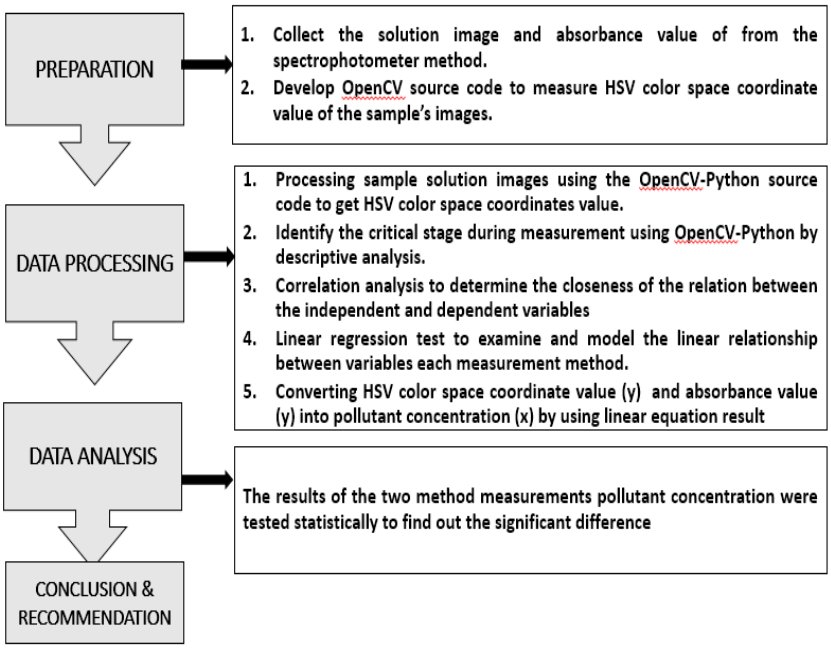

Fig 1 Research Method Flowchart

2.2 Preparation

2.2.1 Data Collection

This research requires two data types which analyze NH_3 Phenate and Pt-Co by using a colorimetry analysis method with the spectrophotometric instrument. First, quantitative data, namely the absorbance values of the standard sample solution from the spectrophotometer device, will be used as a comparison of the results of the sample concentration obtained by the OpenCV method. The second data is the standard sample solution image in the same sample that will be used as an object for sample measurement using OpenCV.

2.2.2 Develop OpenCV code

Developing OpenCV code is the writing a step-by-step instructions OpenCV code that instructs a computer perform tasks to calculate HSV color space coordinate in the sample's images. HSV color space coordinate values are used to measure sample concentration[16][17]. OpenCV algorithm was use to process an image shown in Fig. 2.[14]. If the tasks were mapped to an algorithm, the algorithm was converted to a

specific collection of instructions in python programming language and OpenCV programming function library. Due to its simplicity and readability, the Python programming language needs just a few lines of code compared to other languages[21]. OpenCV code was developed in an Integrated Development Environment (IDE) specific for python that is PyCharm.

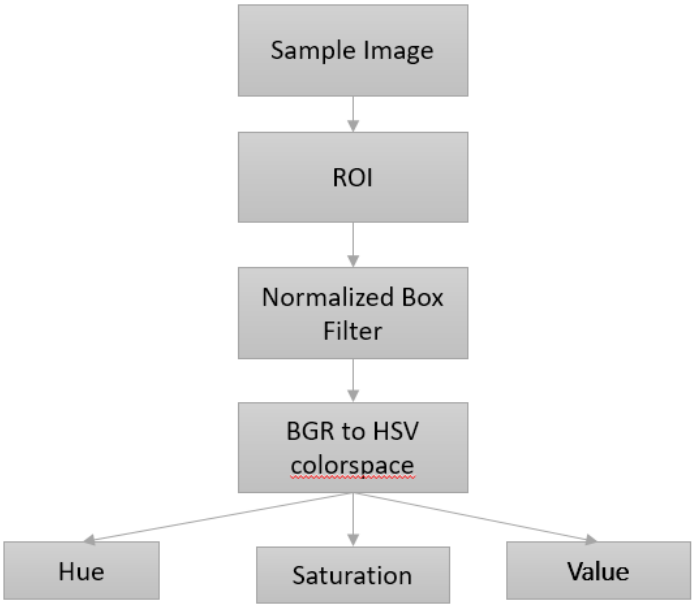

Fig 2. The Algorithm of image processing using OpenCV to calculate HSV color space coordinates value

2.3 Data Processing

2.3.1 NH_3

Phenate and Pt-Co CU measurement using Spectrophotometric

2.3.1.1 Calibration curve linearity

Calibration curve linearity test was performed to prove the linearity of the correlation between the dependent and independent variable. The linear correlation coefficient (r or R) is to measure providing information to the extent to which two variables have a very close association[22]. This research uses Microsoft Excel to show the linear correlation coefficient where it can show a relation between the Absorbance value with the standard calibration of NH_3 Phenate.

2.3.1.2 Linear regression test

By using linear regression, a correlation analysis is supported, which is one of the statistical techniques that include defining and analyzing the relationship between dependent and independent variables. Linear regression considers the best line to estimate the independent variable from the dependent variable [23]. In this research, the independent variable x is the NH_3 and Pt-Co Color Unit (CU) concentration value, whereas the dependent variable y is the Absorbance and HSV color space coordinate value. The linear regression will resulting the determination coefficient, referred to as R^2. It is interpreted the variance of x value, which can be described by the simple linear regression model. And also, the linear regression produces an equation where it is used for calculating the concentration [24].

2.3.2 Factors that influence the Pt-Co sample image measurement process by using OpenCV

The factors that influence the Pt-Co sample image measurement process by using OpenCV-Python source code will be analyzed based on several experiments results by descriptive and literature.

2.3.3 NH_3 Phenate and Pt-Co CU measurement using OpenCV

2.3.3.1 Digital image processing using OpenCV

The digital image processing process stages was presented in Fig. 3 for Pt-Co on light background, Fig. 4 for Pt-Co dark background, and Fig.5 for NH_3 Phenate. The original images were processed at a resolution of 120x240 pixels for Pt-Co on light background (Fig. 3a), 175x75 pixels for Pt-Co on dark background (Fig. 4a) and 40x100 pixels for NH_3 Phenate (Fig. 5a).After that, the Region of Interest (ROI) has been determined at a size of 175x75 pixels for Pt-Co on light background (Fig. 3b), 52x32 pixels for Pt-Co on dark background (Fig. 4b), and 95x30 pixel for NH_3 Phenate. Then, the blur function or normalized box filter is applied to the specified ROI of all samples. In Pt-Co sample images, both average pixel values of ROI is calculated using 200x200 pixels. Meanwhile, in NH_3 Phenate average pixel values of ROI is calculated using 100x100 pixels. In these normalized box filter pixels size, the images generate average and consistent results even though there is a lot of external light

interference from the sample images during the image process. Then, ROI was converted from default color space of OpenCV that is the blue, green, red (BGR) to the Hue, Saturation, Value (HSV) color space (Fig. 3d Pt-Co on light background) (Fig. 4d Pt-Co on dark background) (Fig. 5d NH_3 Phenate).

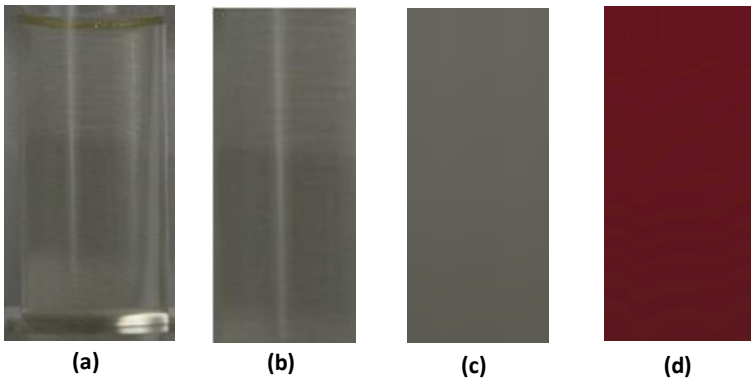

Fig. 1. Digital mage processing using OpenCV on Pt-Co Sample on a light background. (a) Original image (120x240 pixels), (b) ROI (175x75 pixels), (c) Normalized box filter application (200x200 pixels), (d) HSV color space of sample image

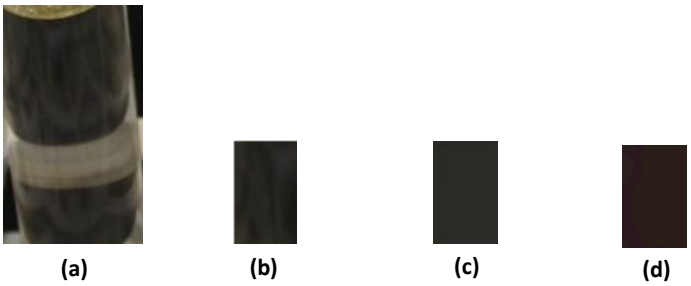

Fig 2. Digital mage processing using OpenCV on Pt-Co Sample on Pt-Co Sample on dark background. (a) Original image (175x75 pixels), (b) ROI (52x32 pixels), (c) Normalized box filter application (200x200 pixels), (d) HSV color space of sample image

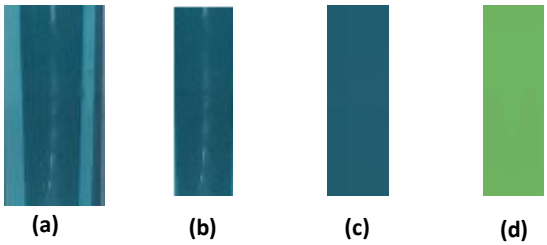

Fig. 5. Digital mage processing using OpenCV on NH_3 Phenate Sample on a (a) Original image (50x100 pixels), (b) ROI (95x30 pixels), (c) Normalized box filter application (100x100 pixels), (d) HSV color space of sample image

Then, from HSV color space of the sample images, the HSV color space coordinate values was calculated.

2.3.3.2 Calibration curve linearity test

This research uses Microsoft Excel to show the linear correlation coefficient where it can show a relation between the HSV color space coordinate value with the standard calibration of the NH_3 Phenate and Pt-Co from spectrophotometer.

2.3.3.3 Linear regression test

In this research, the dependent variable y is HSV color space coordinate and Absorbance value, whereas the dependent variable x is the NH_3 and Pt-Co Color Unit (CU) concentration value. The linear regression will resulting the determination coefficient, referred to as R^2. It is interpreted the variance of x value, which can be described by the simple linear regression model. And also, the linear regression produces an equation where it is used for calculating the sample concentration[24]

2.3.3.4 Data Analysis

The results of the two different measurements method to measure Pt-Co CU and NH_3 phenate concentration values were compared by statistical analysis using an independent t-test method to determine the significant mean difference. If the Significance values (2-tailed) 0.05, then there is no significant difference between the CU values using two different measurements method [25].

The result of this hypothesis testing used to determine the potential method of digital image processing by using OpenCV to measure pollutant concentration. The statistical test was carried using open-source statistical software called Rgui with Rcommander interface.

3 Results and Discussion

3.1 Result and discussion of the preparation

3.1.1 Data collection of the NH_3 phenate by spectrophotometer

The absorbance values of the NH_3 was rerfers to SNI 06-6989.30-2005 how to test ammonia levels with a spectrophotometer in phenate method. The wavelengths for NH_3 phenate standard solution measurement used as the reference point in the UV-Vis spectrophotometer was 640 nm. The absorbance values of the NH_3 standard sample solution presented in Table 1.

Table 1. The Absorbance Values of The NH_3 Standard Sample Solution

Predicted Sample Concentration (ppm)	Absorbance
1	0,43
2	0,835
4	1,794
6	2,119
8	2,432
10	2,482

As shown in Fig. 5a, the same sample of NH_3 solution was capture. Then, the sample images of 6 concentration of NH_3 sample were processed one by one by OpenCV code.

3.1.2 Data collection of the Pt-Co by spectrophotometer

The absorbance values of the Pt-Co standard sample solution from the spectrophotometer device and the standard sample solution image of the same sample that will be used in this study was secondary data from research in 2019 by R. Hakiki and T. Wikaningrum[13]. The researchers was measuring color parameter using Platinum Cobalt (Pt-Co) refers to APHA standard method part 2120. The wavelengths for Pt-Co standard solution measurement used by researcher as the reference point in the UV-Vis spectrophotometer was 317.5 nm. The absorbance values of the sample solution with five concentrations diluted from the 500 Pt-Co unit measurement standard as presented in Table 2.

Table 2. The Absorbance Value of The Pt-Co Standard Sample Solutions

Predicted Sample Concentration (CU)	Absorbance
15	0.146
25	0.233
35	0.272
45	0.342
55	0.402

As shown in Fig. 3a and Fig. 4a, the same sample of Pt-Co solution was captured by the researcher. The images captured by researcher were two images with different background in order to analyze its factor influences[6] Then, the sample images of 5 concentration of Pt-Co sample were processed one by one by OpenCV code.

3.2 Data processing result and discussion

3.2.1 Data collection of the NH_3 phenate and Pt-Co measurement by using spectrophotometer

3.2.1.1 Calibration curve linearity test

The calculation of the correlation coefficient is done in Microsoft Excel where the function "CORREL" was used. And select the two variables to get the value of correlation.

Table 3. Data of Calibration Curve Linearity Test

Calibration standard sample	Parameter		Term of Acceptance
	r	***R***	
Pt-Co	0.995	0.990	> 0.90
NH_3 Phenate	0.884	0.942	

The variables absorbance value with the standard calibration of NH_3 Phenate have the correlation value (r) of 0.947 which means there is a strong relationship between the variables, meanwhile the correlation determination (R) of 0.884 which not supported the strong relationship between absorbance value and NH_3 calibration standard. In other hand, The variables absorbance value with the standard calibration of Pt-Co have the correlation value (r) of 0.995 and correlation determination (R) of 0.990 which means there is a strong relationship between the variables.

3.2.1.2 Linear regression test

In this study the dependent and independent variable are:

1. Independent Variable (x) : Pt-Co CU value and NH_3 concentration (ppm)
2. Dependent Variable (y) : Absorbance value

These two variables are then plotted into the scatter graph by using Microsoft Excel resulting the trendline, linear regression equation, and the coefficient of determination (R^2).

The plot graph of linear regression result of 5 Pt-Co sample solution absorbance values with its predicted sample concentration (CU) shown in Fig. 6. The coefficient determination values (R^2) is 0.99, indicating that the predicted sample concentration (CU) is proportional to the Pt-Co absorbance values. It means that the two variables have a huge relation and the independent variable (x) can be explained by dependent variable (y). From this graph, the linear regression equation to calculate concentration is obtained, as shown in equation (1).

$$y=0{,}0062x + 0.0616 \quad (1)$$

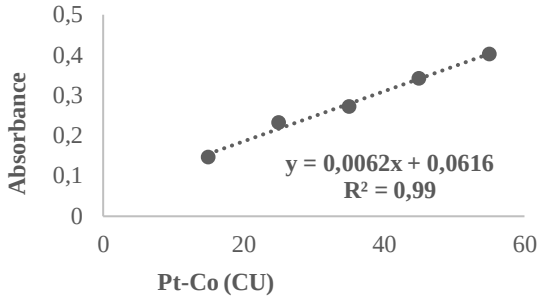

Fig. 3. The Plot Graph of Linear Regression Result of 5 Pt-Co Absorbance Values and its Pt-Co Predicted Concentration (CU)

Then, the Absorbance value of Pt-Co from spectrophotometer was used to calculate Pt-Co CU concentration value, by substitusing the Absorbance value into equation 1. The result of Pt-Co CU concentration value from absorbance value presented in Table 3.

Table 4. Result of Pt-Co CU Values from Absorbance Value

Predicted Sample Concentration (CU)	Absorbance	Calculated Concentration (CU)
15	0.146	13.6
25	0.233	26.0
35	0.272	33.9
45	0.342	45.2
55	0.402	54.9

The plot graph of linear regression result of 6 NH_3 phenate sample solution absorbance values with its predicted sample concentration (CU) shown in Fig. 7. The coefficient determination values (R^2) is 0.88, indicating that the predicted sample concentration (CU) is not proportional to the NH_3 phenate absorbance values. It has poorly related variable and the independent variable (x) can not be explained by dependent variable (y). From this graph, the linear regression equation to calculate concentration is obtained but can not use to predict the sample concentration, as shown in equation (2).

$$y = 0{,}2322x + 0{,}4824 \quad (2)$$

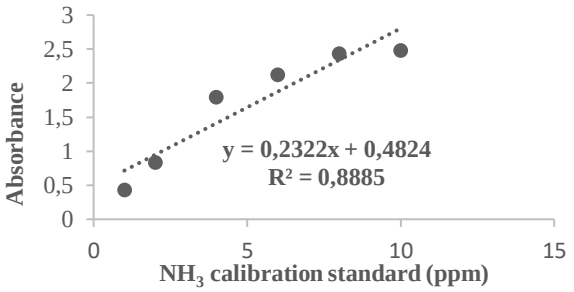

Fig. 7. The Plot Graph of Linear Regression Result of NH_3 phenate Absorbance Values and its Predicted Concentration (ppm)

3.2.2 Factors that influence the Pt-Co sample image measurement process by using OpenCV

Based on the measurement experiments, the Region Of Interest (ROI), and specified the pixel values for the normalized Box filter. OpenCV code used to measure NH_3 phenate and Pt-Co is the same code; the difference is only in determining ROI and Normalized box filter pixel value which is selected based on the shooting conditions and sample images to be processed. In similar way, with the use of different backgrounds condition in the sample image, the OpenCV code still use the same code, the difference lies in the determination of the ROI and the pixel values of the normalized box filter.

It is important to choose the region of interest (ROI) carefully , so certain image areas must be chosen with the ROI feature to increase accurate measurement, so that areas which do not want to be measured, such as shadows, can't be taken away. Moreover, it's necessary to determine the pixel values of the Normalized Box Filter because the normalized box filter feature helps remove external distractions, including shooting, shadows and edges unstable. Thus, the selected ROI and pixel values of the normalized box filter affect HSV color space values and the resulting value for concentration. After several experiments were carried out with several differences in ROI and normalized box filter pixels, the ROI selected was the area with minimum interference and specified the pixel values of normalized box filter at the optimum result which proved by the result with the highest coefficient determination.

3.2.3 NH3 Phenate and Pt-Co CU measurement using OpenCV

3.2.3.1 Digital image processing using OpenCV

The HSV color space coordinate values of 5 Pt-Co sample images was calculated by the OpenCV and dark background are presented in Table V and for NH_3 phenate are presented in table VI. And then the HSV color space coordinate value were plotted into a scatter graph to test the linear regression.

Table 5. The HSV Color Space Coordinate Values of Pt-Co Sample Solution Image measurement by OpenCV

Predicted Sample Concentration (CU)	HSV on Light Background			HSV on Dark Background		
	H	***S***	***V***	***H***	***S***	***V***
15	30	25	92	24	29	44
25	30	29	98	21	36	48
35	30	29	98	29	48	43
45	30	33	100	20	53	43
55	28	35	94	20	60	38

Table 6. The HSV Color Space Coordinate Values of NH_3 Phenat Sample Solution Image measurement by OpenCV

Predicted Sample Concentration (ppm)	H	S	V
1	97	177	111
2	103	190	98
4	109	178	79
6	115	153	65
8	119	134	57
10	120	116	55

3.2.3.2 Calibration curve linearity test

As presented in Table VII, the variables Hue value with the standard calibration of NH_3 Phenate have the correlation value (r) 0.968 of which means there is a strong relationship between the variables, in similar way the correlation determination (R) 0.938 shows the strong relationship between Hue value and NH_3 calibration standard. In other hand, The variables Saturation value with the standard calibration of Pt-Co have the correlation value (r) of 0.973 and correlation determination (R) of 0.947 which means there is a strong relationship between the variables.

Table 7. Data of Calibration Curve Linearity Test

Calibration standard sample	Parameter		Term of Acceptance
	r	*R*	
Pt-Co	0.973	0.947	> 0.90
NH_3 Phenate	0,968	0,938	

3.2.3.3 Linear regression test

The result of linear regression test for Pt-Co standar solution on light and dark background, the HSV coordinate value and with predicted sample concentration shows that the Saturation coordinate values are proven the most proportional coordinate than Hue and Values for predict Pt-Co CU concentration, as it is proportional to the Pt-Co predicted sample concentration in the sample. The graph shown in Fig. 8 for light background and Fig. 9 for dark background. In this case, coefficient determination (R^2) from Pt-Co on light background obtained was 0.94, coefficient determination (R^2) from Pt-Co on dark background obtained was 0.98. From the results of plotting the saturation values, a linear regression equation is obtained (3) for light background and equation (4) for dark background.

$$y = 0.24x + 21.8 \quad (3)$$

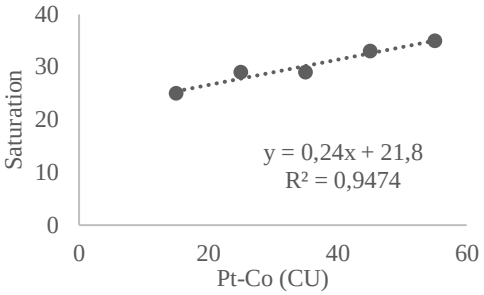

Fig. 8. The Plot Graph of Linear Regression Result of Pt-Co Saturation coordinate Values and its Predicted Concentration (CU)
(light background)

$$y = 0.79x + 17.55 \quad (4)$$

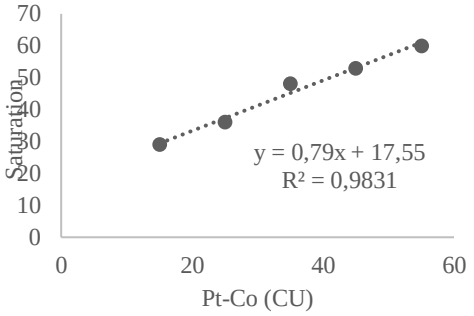

Fig. 9. The Plot Graph of Linear Regression Result of Pt-Co Saturation coordinate Values and its Predicted Concentration (CU)
(dark background)

Then, the Saturation color space coordinate values was used to calculate CU values which results are presented in Table VIII.

Table 8. Pt-Co Cu Value From OpenCV Measurement

Predicted Sample Concentration (CU)	Calculated Concentration CU (Dark Background)	Calculated Concentration CU (Light Background)
15	14.49	13.3
25	23.35	30.0
35	48.54	30.0
45	44.87	46.7
55	53.73	55.0

The result of linear regression test for NH_3 phenate standar solution, the HSV coordinate value and with predicted sample concentration shows that the Hue

coordinate values are proven the most proportional coordinate than Saturation and Values for predict NH_3 concentration, as it is proportional to the NH_3 predicted sample concentration in the sample. The graph shown in Fig. 10. In this case, coefficient determination (R^2) obtained was 0.93 its different with the result from spectrophotometer that non-linear. from the results of plotting the saturation values, a linear regression equation is obtained (5).

$$y = 02.5562x + 97.293 \quad (5)$$

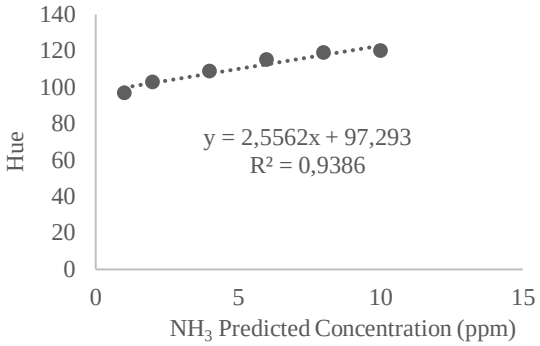

Fig. 10. The Plot Graph of Linear Regression Result of NH_3 Hue coordinate Values and its Predicted Concentration(CU)

3.3 Data analysis result and discussion

The calculated concentration CU values of the Pt-Co sample solutions for each light and dark background as determined by two different measurement methods was then statistically tested using the independent t-test method to determine significant mean differences. Based on statistical test results presented in Fig, 11 and Fig. 12, using decision making based on p-values at alpha 0.05. As a result, the p-values for both Pt-Co CU values for light and dark background sample data is > 0.05. It means that both using light and dark background, there is no significant difference in the spectrophotometric method results and the results from OpenCV,

```
        Two Sample t-test

data:  CU by Method
t = 0.0063433, df = 8, p-value = 0.9951
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -23.38923  23.51826
sample estimates:
mean in group CU from Abs   mean in group CU from S
                 35.06452                  35.00000
```

Fig. 11. The output of RGui for independent t-test of measurement CU from Absorbance and CU from Saturation (Light Background)

```
        Two Sample t-test

data:  CU by Method
t = 0.006403, df = 8, p-value = 0.995
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -23.17049  23.29952
sample estimates:
mean in group CU from Abs   mean in group CU from S
                 35.06452                  35.00000
```

Fig. 12. The output of RGui for independent t-test of measurement CU from Absorbance and CU from Saturation (Dark Background)

4 Conclusion

The results from this study found that the OpenCV has potential to be use as alternative colorimetry analysis method to determine water pollutant as there is no significant difference in the spectrophotometric method results and the results from OpenCV for Pt-Co sample. Meanwhile, in this study found that the result of NH_3 from spectrophotometer is nonlinear different with from OpenCV that is linear, Thus, further research is needed to test the validity of OpenCV method. The factor influence of measurement using OpenCV code is when determining the Region of Interest (ROI) and determining the pixel values for the normalized box filter. Selecting the Region of Interest (ROI) is critical because certain areas in the image as the area to be measured need to be selected with the ROI function to improve accuracy. The OpenCV code for measure sample in any condition background is the same code, in similar way all parameter measurement use the same OpenCV code. The difference only lies on determination ROI and normalized box filter value. Besides, the linearity of the measurement result from spectrophotometer should be considered.

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