

Spectrophotometric Determination of Hexavalent Chromium in Bago River Water

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Abstract

In this research, hexavalent chromium in Bago River water was determined by spectrophotometric method. Collections of the samples were carried out during December 2019. Six sampling sites were chosen and the samples were collected in a clean plastic bottle. The distance between the first sample collection site and the last site is about 4.7 km. For chromium determination, spectrophotometric method based on the formation of coloured complex between Cr (VI) and 1,5-diphenylcarbazide were used. Firstly, the wavelength of maximum absorption (λ_{\max}) of the colour complex was determined and the λ_{\max} value was found as 540 nm. For the standard calibration curve, seven different concentrations of chromium (VI) standard solutions were prepared and their absorbances were measured. Linearity was tested by linear regression of the responses on the concentration range of 0.10 ppm to 0.80 ppm. The correlation coefficient, R^2 obtained was 0.9984 and showed a good linearity of the calibration graph. For the quality control of the method, the two statistical parameters: limit of detection (LOD) and limit of quantification (LOQ) were determined from regression line. The values of LOD and LOQ were observed as 0.037 ppm and 0.124 ppm respectively. The observed values of Cr (VI) in sampling sites S1 and S2 were lower than the LOD limit. These sampling sites S1 and S2 were the place where the river water before entering the Bago City. But in the other four sampling sites, the chromium values observed were greater than the LOQ limit. The observed values showed that the Cr (VI) concentration increased significantly in the sampling sites S3, S4, S5, and S6. These four sampling sites were located in the centre of city and Bago River leaving from the city. Therefore, the chromium pollution found in this river water may be due to the discharge of wastewater directly into the Bago River

Keywords: hexavalent chromium, 1,5 diphenylcarbazide , Bago River water, municipal sewage, spectrophotometric method

1. Introduction

Hexavalent chromium is one of the toxic heavy metals with high mobility in soil and ground water which can produce harmful effects on organisms including humans. Hexavalent chromium [Cr (VI)] compounds are used in a wide variety of commercial process such as chromite ore processing, electroplating and leather-tanning processes (Laurie, 2012).

1.1 Environmental Effects and Health Effects

Chromium can occur as Cr(III) and Cr(VI) in dissolved form with different concentrations in all kinds of waters. Cr(VI) has high environmental mobility and can originate from anthropogenic and natural sources (Vinita, 2007). Cr (VI) is more toxic than Cr (III) and is of specific interest. Chromium (VI) is a known carcinogenic contaminant and toxic in low concentration. Chromium is used in plastic, ceramic, steel and textile dyes.

Cr (VI) is soluble and toxic in low concentrations (Marr, 2001). Cr(III) is considered nontoxic, even in relatively high concentrations and is an essential trace element required for the maintenance of glucose, lipid and protein metabolism .

2. Materials and Methods

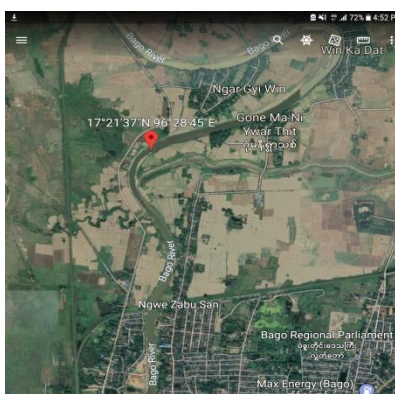
2.1 Collection of Samples

Collections of the sample were carried out during December 2019. The Six sampling sites were chosen and the samples were collected in a clean plastic bottle.

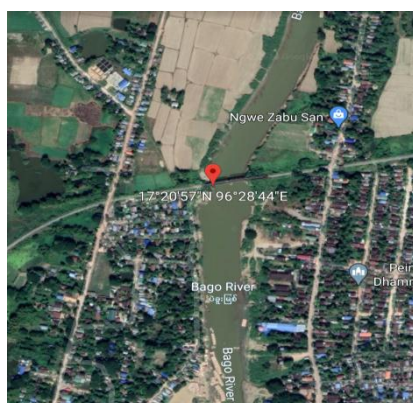
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Table 2.1 Sampling Locations of the Six Different Sampling Sites

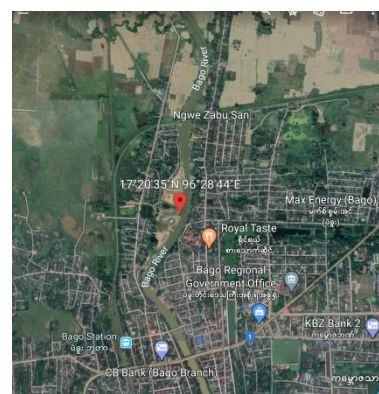
| Sampling site | Sampling location |
|--------------------|--------------------------|
| Sampling site (S1) | 17°21'37"N 96°28'45 " E |
| Sampling site (S2) | 17°20'57"N 96°28'44 " E |
| Sampling site (S3) | 17°20'35"N 96°28'44 " E |
| Sampling site (S4) | 17°20'02 "N 96°28'45 " E |
| Sampling site (S5) | 17°19'49"N 96°28'52 " E |
| Sampling site (S6) | 17°19'13 "N 96°28'54 " E |



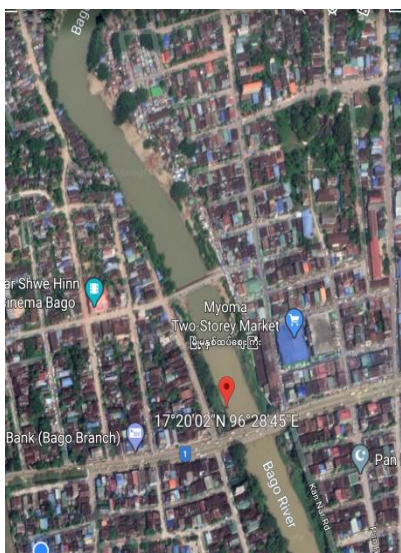
(a)



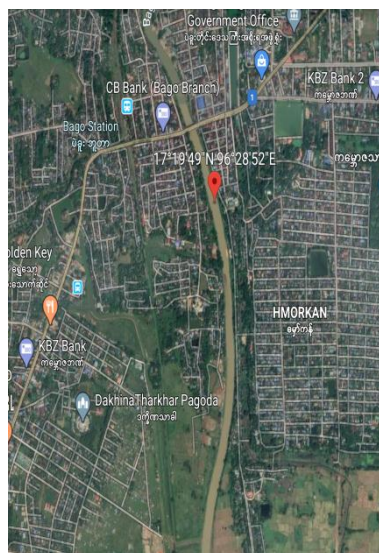
(b)



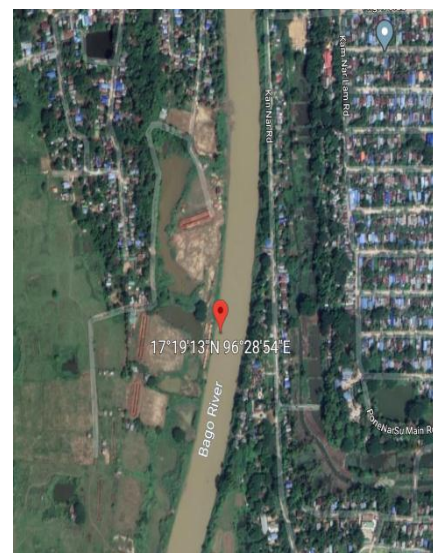
(c)



(d)



(e)



(f)

Figure 2.1 Satellite image of the six sampling sites (a) sampling site S1 (b) sampling site S2 (c) sampling site S3 (d) sampling site S4 (e) sampling site S5 (f) sampling site S6

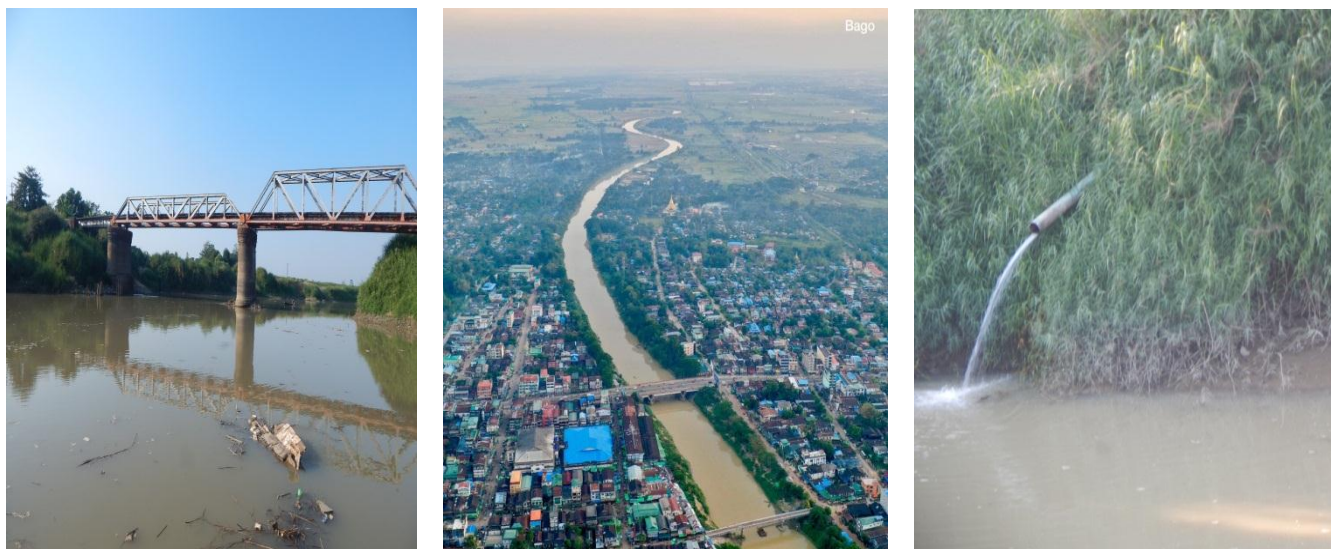


Figure 2.3 Photographs of the some point view of Bago River

2.2 Sample Preparation

The collected water samples were filtered to remove suspended particles prior to analysis.

2.3 Determination of Hexavalent Chromium Concentration in the Bago River water

2.3.1 Determination of wavelength of maximum absorption of chromium-1,5 diphenylcarbazide complex

2.3.1.1 Chemicals

Potassium dichromate, 1-5 diphenylcarbazide, acetone, sulphuric acid were used.

2.3.1.2 Preparation of solutions

2.3.1.2 (a) Potassium dichromate stock solution (500 mg/L)

Dried potassium dichromate (0.1414 g) was dissolved in distilled water and diluted up to the mark with distilled water in 100 mL volumetric flask.

2.3.1.2 (b) Potassium dichromate working solution (5 mg/L)

1 mL of stock chromium solution (500 mg/mL) was diluted to 100 mL with distilled water in 100 mL volumetric flask.

2.3.1.2 (c) 1,5 Diphenylcarbazide solution

1,5-diphenylcarbazide $C_{13}H_{14}N_4O$ (0.250 g) was weighed and then dissolved into 50 mL acetone and stored in a dark brown bottle.

2.3.1.2 (d) Sulphuric acid solution

Sulphuric acid (0.2 N) was prepared by adding 20 ml of deionized water into 100 mL of volumetric flask and then dissolved 0.56 mL concentrated sulphuric acid into it. Then, the volume was made up to mark with deionized water.

1.3.1.3 Apparatus

Micropipette, volumetric flask (10 mL, 100 mL), analytical balance, spectrophotometer (UV-Vis 2600) were used.

2.3.1.4 Procedure

0.40 mL of chromium working solution (5 mg/mL) was added to the 10 mL volumetric flask and then 5 mL distilled water was added. Then 0.25 mL of sulphuric acid solution, 0.2 mL of 1,5 diphenylcarbazide solution were added and the volume was made up to mark with distilled water. The resulting solution was allowed to stand about 10 min for colour development.

The absorption spectrum was recorded between 600 nm to 400 nm by UV-2600 spectrophotometer. The reagent blank solution was placed in the reference holder and the sample was placed in the sample cell holder and the spectrum was recorded.

2.3.2 Construction of standard calibration curve for the hexavalent chromium determination

Firstly, different volume of 5.0 ppm stock hexavalent solution (0.20, 0.40, 0.80, 1.0, 1.20, 1.60, 2.00 mL) was added to the 10 mL volumetric flask and then 5 mL distilled water was added. Then 0.25 mL of sulphuric solution, 0.2 mL of 1,5 diphenyl carbazide solution were added and the volume make up to mark with distilled water. The resulting solution was allowed to stand about 10 min for colour development.

Absorbance of the resulting solution was measured against reagent blank at 540 nm by using UV spectrophotometer (UV-2600). A standard curve was prepared by plotting the absorbance against concentrations of hexavalent chromium.

2.3.3 Determination of hexavalent chromium concentration in the water sample

The sample solution 5 mL was added to the 10 mL volumetric flask and then 0.25 mL of sulphuric acid solution, 0.2 mL of 1,5 diphenyl carbazide solution were added and the volume was made up to mark with sample solution again. The resulting solution was allowed to stand about 10 min for colour development.

Absorbance of the resulting solution was measured against reagent blank at 540 nm by using UV spectrophotometer (UV-2600). The concentration of the sample solution was calculated from the linear equation obtained from standard calibration curve.

3. Results and Discussion

3.1 Determination of Wavelength of Maximum absorption of chromium-1,5 diphenyl carbazide complex

For the determination of λ_{\max} value for the chromium-1,5 diphenylcarbazide complex, 0.1 ppm complex solution was prepared and the absorption spectrum was recorded against reagent blank solution in the wavelength range of 600 nm to 400 nm. The wavelength of maximum absorption was obtained as 540 nm (Figure 3.1).

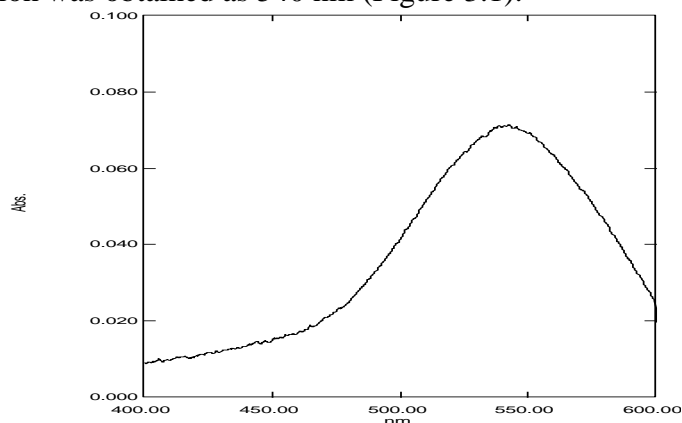


Figure 3.1 Absorption spectrum of chromium-1,5 diphenyl carbazide complex

3.2 Construction of Standard Calibration Curve for the Hexavalent Chromium Determination

Seven different concentrations of hexavalent chromium (0.10, 0.20, 0.40, 0.50, 0.60, 0.80, 1.00 ppm) were prepared and their absorbances were measured at 540 nm against reagent blank by UV-2600 spectrophotometer. The standard calibration curve was constructed by plotting absorbance Vs concentration of the each standard solution.

Linearity was tested by linear regression of the responses on the concentration range of 0.10 ppm to 0.80 ppm. The correlation coefficient, R^2 was 0.9984 and showed a good linearity of the calibration graph which is almost near to 1.0000. For the quality control of the method, the two statistical parameters: Limit of detection (LOD) and limit of quantification

(LOQ) were determined from regression line. The values of LOD and LOQ were observed as 0.037 ppm and 0.124 ppm respectively (Table 3.1, Figure 3.2).

Table 3.1 Absorbance Values of the Calibration Points for the Determination of Hexavalent Chromium

| No. | Concentration (ppm) | Absorbance at 540 nm |
|-----|---------------------|----------------------|
| 1 | 0.0 | 0.002 |
| 2 | 0.1 | 0.020 |
| 3 | 0.2 | 0.035 |
| 4 | 0.4 | 0.062 |
| 5 | 0.5 | 0.079 |
| 6 | 0.6 | 0.090 |
| 7 | 0.8 | 0.120 |

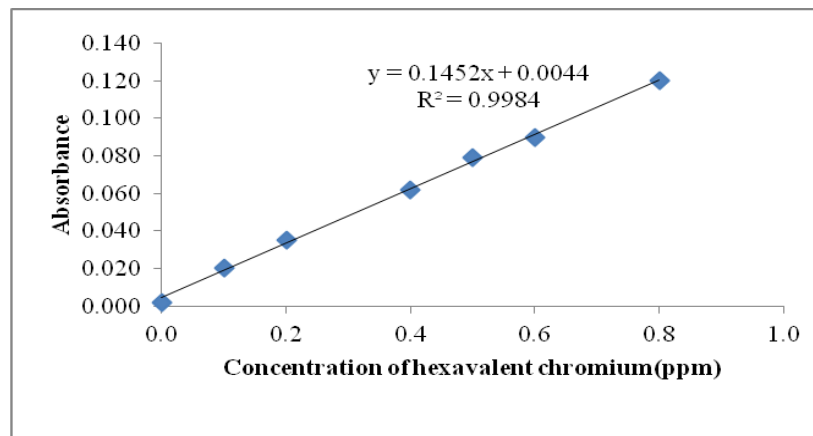


Figure 3.2 Standard calibration curve for the determination of hexavalent chromium

3.3 Determination of Hexavalent Chromium in Bago River Water

The water samples were collected from the six different sites of the Bago River water. All the performed analyses were carried out in triplicate and the standard deviation (SD) was calculated. The observed concentration of chromium (VI) was 0.013 ± 0.004 ppm in the sampling site S1, 0.016 ± 0.004 ppm in site S2, 0.376 ± 0.012 ppm in site S3, 0.544 ± 0.024 ppm in site S4, 0.466 ± 0.036 in sampling site S5 and 0.454 ± 0.011 in sampling site S6 respectively. The highest value of chromium was found in the sampling site S4 and the lowest value was found in S1. (Table 3.2, Figure 3.3).

Table 3.2 Concentration of Hexavalent Chromium in the Six Different Sampling Sites

| No | Sampling site | Concentration of chromium (ppm) |
|----|--------------------|---------------------------------|
| 1 | Sampling site (S1) | 0.013 ± 0.004 |
| 2 | Sampling site (S2) | 0.016 ± 0.004 |
| 3 | Sampling site (S3) | 0.376 ± 0.012 |
| 4 | Sampling site (S4) | 0.544 ± 0.024 |
| 5 | Sampling site (S5) | 0.466 ± 0.036 |
| 6 | Sampling site (S6) | 0.454 ± 0.011 |

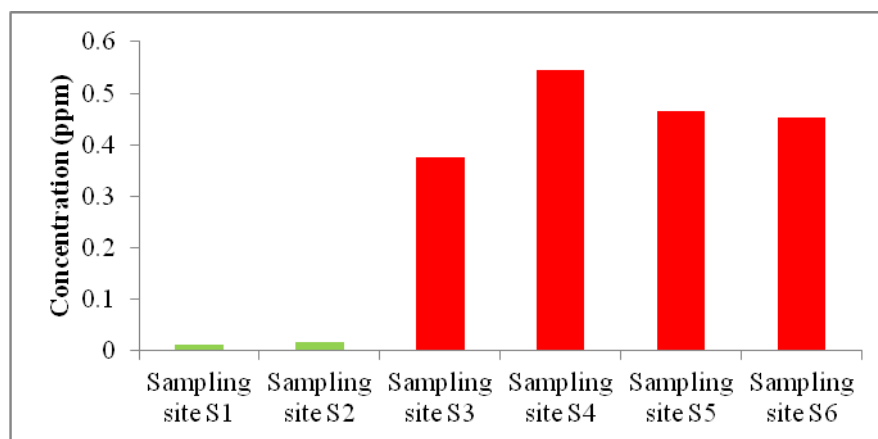


Figure 3.3 Histogram of the concentration of hexavalent chromium in six sampling sites

4. Conclusion

The wavelength of maximum absorption (λ_{\max}) of the chromium-1,5 diphenylcarbazide was determined the λ_{\max} value was found as 540 nm. For the standard calibration curve, seven different concentration of chromium (VI) standard solutions were prepared and their absorbance were measured. Linearity was tested by linear regression of the responses on the concentration range of 0.10 ppm to 0.80 ppm. The correlation coefficient, R^2 was 0.9984 and showed a good linearity of the calibration graph. For the quality control of the method, the two statistical parameters: Limit of detection (LOD) and limit of quantification (LOQ) were determined from regression line. The values of LOD and LOQ were observed as 0.037 ppm and 0.124 ppm respectively. The observed values of Cr (VI) in sampling sites S1 and S2 were lower than the LOD limit. These sampling sites S1 and S2 were the place where the river water before entering the Bago City. But in the other four sampling sites, the chromium values observed were greater than the LOQ limit. The observed values showed that the Cr (VI) concentration increased significantly in the sampling sites S3, S4, S5, and S6. These four sampling sites were located in the centre of city and Bago River leaving from the city. Therefore, the chromium pollution found in this river water may be due to the discharge of wastewater directly into the Bago River.

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