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Determination Of Phenol In Natural Water Samples In Kano Metrolpolis

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Abstract: ***In this study, total phenols were determined by molecular spectrophotometry, after steam distillation, complexation with 4-aminoantipyrene and extraction into trichloromethane. The dynamic range was 0 - 300 mg/L. The experimental method was applied in the analysis of environmental samples (river water, well water and groundwater) collected within Kano metropolis of Kano State, Nigeria. Significant amount of phenols were found in the natural water samples with a range of 0.4384 - 1 mg/L. The results indicated high pollution of phenol as the values exceeded the tolerance level of 0.0005 mg/L and maximum permissible limit on phenol in drinking water set by US, Canada and Japan of 0.001mg/L, 0.00 2mg/L and 0.005mg/L respectively. It also exceeded the world health organization's (WHO) Guidelines for drinking water quality which gives the level of phenols as 0.001 mg/L. The qualities of natural waters were impaired in terms of phenol and therefore the need for post treatment to make them safe for water intended for human consumption. The water bodies should also be monitored from time to time to ascertain the level of phenol.***

Keywords: Waters; phenol; level; spectrophotometry; 4-aminoantipyrene; safe.

I. INTRODUCTION

Phenol and phenolic compounds are common contaminants in the effluents from industries such as plastics, leather, paint, textile and petrochemical (Kennedy et al., 2007). The health effects following repeated exposure to low levels of phenol in water include liver damage, diarrhea, dark urine and mouth ulcer. Also, phenol is a strong eye and respiratory irritants. Phenolic compounds are harmful to organism at low concentrations and many of them have been classified as hazardous pollutants (Calace et al., 2002). The methods used for the treatment of aqueous solutions containing phenol have been classified in two principal categories: destructive processes such as destructive oxidation with ozone, enzymebased treatment methods and electrochemical oxidation; and recuperative processes such as adsorption, membrane separation and ion exchange (Kermani et al., 2006; Dabrowski et al., 2005; Bodalo et al., 2006; Laszlo et al., 2007). Among these, adsorption onto the activated carbon is the most widely used method for the removal of dissolved organics from waters. Activated carbon posses perfect adsorption ability for relatively low molecular weight organic compounds such as phenols (Dabrowski et al., 2005).

Eleven common phenols: pentachlorophenol, 4-chloro-3methylphenol, 2,4,6-trichlorophenol, 2,4dichlorophenol 2,4-dinitrophenol, 2-methyl-4,6dinitrophenol, 4-nitrophenol, 2,4-dimethylphenol, 2-nitrophenol, 2-chlorophenol and phenol have been included in the lists of priority pollutants [U.S. Environmental Protection Agency, 2007]. Excessive presence of phenol and its derivatives in natural water sources is considered a serious threat to human health and overall water quality [Bhatnagar, 2007].

Quality assessment of natural waters in Kano metropolis, Kano State, Nigeria has faced serious neglect over the years with no or scanty work cited in literatures. This work is poised to investigate the concentrations of total phenol in natural waters intended for human consumption.

II. MATERIALS AND METHODS

MATERIALS

All reagents were analytical grade. All plastic and glassware utilized were pre-washed with detergent water solution and rinsed with tap water.

SAMPLING METHODS

Natural water samples were collected from Bagwai river(BR), Challawa river(CR), and well-water(WW). The sample point was in Kano metropolis of Kano State. The samples were obtained by grab sampling technique following procedures described by [Ademoroti, 1996].

PREPARATION OF ANALYTICAL REAGENTS

All analytical reagents were prepared with boiled distilled water following standard procedures. Working standards were prepared from sock standard.

STANDARDIZATION OF PHENOL

Phenol was standardized by bromination of phenol following standard procedure adopted by [Ademoroti, 1996]. 1.000 g of phenol was accurately weighed and dissolved in one litre volumetric flask using distilled water and made up to the mark and labeled as stock standard. 20 mL of phenol from the stock standard solution was taken in an iodine flask, 40 mL of distilled water, 20 mL of Winkler's solution [KBr + KBrO3] were added and the flask was shaken. Then 5 mL of concentrated hydrochloric acid was added and allowed to stand for 10 minutes after which 10 mL of $K_3[Fe(CN)_6]$ solution was added. The mixture was titrated against sodium thiosulphate (that was initially standardised by potassium dichromate) until the colour changed to pale yellow, then 2 drops of starch indicator was added and the titration continued until the first colour disappeared. The burette reading was recorded. The titration was repeated with fresh samples until three concordance readings were obtained.

Phenol concentration was calculated using the formula:

Phenol (mg/L) = 7.842[(AB- C)].

Where

A= Volume of sodium thiosulphate used for the blank

B = Volume of Winkler's reagent used for the sample divided by 10

C = Volume of sodium thiosulphate used for the sample

CONSTRUCTION OF CALIBRATION CURVE

Calibration linearity for phenol determination was investigated by making replicates of five different concentrations. Calibration curve was constructed using working standards of phenol and a blank following standard method adopted by [Ademoroti, 1996]. 300 mL distilled water blank and a series of 300 mL phenol standards containing 100 mg, 150 mg, 200 mg, 250 mg and 300 mg phenol. To the blank and standards, 10 mL of the buffer solution was added to each and the pH adjusted to about pH 10. The solution was transferred into 500 mL separating funnel, followed by the addition of 3 mL of 4-aminoantipyrene and 3 mL of potassium ferric cyanide solution thoroughly mixed and allowed to stand for 10 minutes to develop colour. The colour was extracted with 20 mL trichloromethane added to the separating funnel and shaken 20 times twice. Each extract was filtered with Whatman No. 42 filter paper containing 5g layer of anhydrous sodium sulphate and the dry extracts were collected into clean conical flasks. The dry extracts were analysed at a wavelength of 510 nm on T-60 UV-Visible spectrophotometer (Model 2007, made in United Kingdom). Phenol concentration was calculated by the formula:

$$\text{Phenol (mg/L)} = \frac{\text{Instrument reading (mg/L)} \times \text{dilution factor}}{\text{mL of sample used for colorimetric analysis}}$$

DETERMINATION OF PHENOL IN NATURAL WATERS BY STEAM DISTILLATION

The analytical procedure adopted was similar to that recommended by [American Society for Testing and Materials (ASTM) and American Public Health Association (APH)] with modification. An aliquot of 300 mL of the sample was transferred in a round bottom flask and a side condenser was fitted to the flask. The solution was heated by a mantle until 275 mL of distillate were collected. Addition of some 50 mL of distilled water in the flask was followed, to finish the steam-distillation until 300 mL of total distillate volume was collected. 300 mL of the sample was taken in triplicates to which 10 mL of buffer solution was added to each sample and pH adjusted to 10. The solution was transferred into 500 mL separating funnel, followed by the addition of 3 mL of 4-aminoantipyrene and 3 mL of potassium ferric cyanide solution thoroughly mixed and allowed to stand for 10 minutes to develop colour. The colour was extracted with 20 mL trichloromethane added to the separating funnel and shaken 20 times twice. Each extract was filtered with Whatman No. 42 filter paper containing 5g layer of anhydrous sodium sulphate and the dry extracts were collected into clean conical flasks. The dry extracts were analysed at a wavelength of 510 nm on UV Visible T-60 spectrophotometer (2007 model, made in United Kingdom).

Calculation,

mg/L Phenol = Instrument reading (mg/L) × dilution factor mL of sample used for colorimetric analysis

III. RESULTS AND DISCUSSION

STANDARDISATION OF PHENOL VIA TITRIMETRIC METHOD

The result obtained from the standardisation of phenol by titrimetric titration was 817.69 mg/L served as the concentration of the stock standard and indicated that the phenol used in the work was of high quality (81.77%). This determination was crucial to obtaining working standards which were used to construct calibration curve for the determination of the concentration phenol in water on UV-Visible spectrophotometer.

CALIBRATION CURVE

The calibration curve obtained by a series of aqueous standards of phenols was linear. The results are shown in Table 1 and curve displayed in Fig. 1.

The regression equation was C=206.84A- 0.9554 and the correlation coefficient was r =0.9999 which was very close to unity. The slope of the calibration curve (change in the response signal per unit analyte concentration) is the calibration sensitivity [Skoog et al, 2004]. The calibration curve was linear and therefore sensitivity was constant and independent of concentration. The calibration sensitivity was found to be 206.84A and a linear dynamic range of 0–300 mg/L.

Concentration (mg/L)	Absorbance
50	0.096
100	0.1965
200	0.4020
250	0.5140
300	0.6120

Table 1: Calibration curve

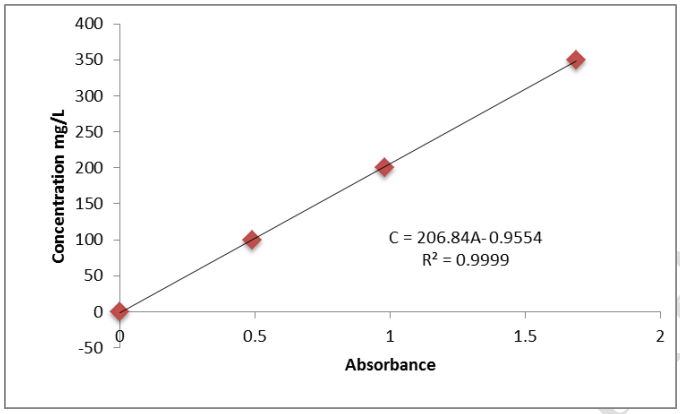

Figure 1: Calibration curve for the determination of phenol in water

DETERMINATION OF PHENOL IN NATURAL WATERS

The results obtained for the determination of phenol in natural waters is displayed on Table 2. The results were of high precision as indicated by low coefficient variation (CV) being less than 5% (Table 2). It has been reported in literature that coefficient of variation of 5% or less connotes good method performance [Westgard et al, 1998]. Earlier investigators have reported values of phenol concentration in the range of 0.004 – 0.012 mg/L for rivers, lakes and stream waters located in Northern Greece [Michael et al, 2000]. The values of phenol concentration in natural waters obtained in this work were considerably higher compared with those reported by [Michael et al, 2000]. Although another researcher [Loreta Vallaja, 2011] reported a higher value of 1 mg/L for phenol in tap water. The high load of phenol in all the water samples used in the work was due to contamination from washing of motorcycles, automobiles, bicycles, clothing bathing, municipal and industrial discharges etc. The Bagwai river had lower concentration of phenol compared to those of the well water and Challawa river (Table 2). This may be due to less pollution from industrial sources such as petroleum products from washing of automobiles and insecticide, herbicide, fungicide and pesticide remains from agricultural activities.

Water type	CON C1	CON C2	Average	Standard deviation (SD)	RSD	Coefficient variation (CV) %
BR	9.38	9.59	9.49	0.4384	0.0154	1.54
CR	16.84	17.18	16.84	0.7283 0.43841	0.01427 0.01277	 1.43
WW	11.34	11.55	11.33	1	1	1.28

Table 2: The concentrations of total phenol in natural waters

The presence of phenol even in low concentration of 1 ppb, some phenols in drinking water supplies have been reported to lead to objectionably tasting and odoriferous chlorophenols on chlorination [Loreta Vallaja,2011]. The detrimental health implications of the toxicity of phenol cannot be compromised. Phenol and its vapour have been reported to be corrosive to the eyes, skin, the respiratory tract; inhalation of phenol vapour may cause lung excessive accumulation of serum in tissues [Budavari, 1996]. It also has harmful effects on the central nervous system and the heart resulting in seizures and coma [Warner et al, 1885]. Long-term or repeated exposure may have harmful effects on liver and kidneys and there is no evidence that phenol causes cancer in humans [Budavari, 1996].

IV. CONCLUSION

The result obtained from this study shows significant amount of phenols were found in the natural water samples with a range of 0.4384 - 1 mg/L. The maximum permissible limit on phenol in drinking water set by US, Canada and Japan is 0.001mg/L, 0.00 2mg/L and 0.005mg/L respectively. The world health organization's (WHO) Guidelines for drinking water quality gives the level of phenols as 0.001 mg/L. Water treatment agencies must take into cognizance the need of post treatment of water bearing phenol to make it free of odour and bitter taste on chlorination thereby making the water safe for municipal water supplies intended for human consumption.

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REFERENCES

[1] Ademoroti CMA. 1996 Standard methods of treatment of water and wastewaters. Fodulex Press Ltd., Ibadan.146-148.

[2] American Society for Testing and Materials (ASTM). 1992 Annual of Book of ASTM Standards. Standard Test methods for phenols.11.02 water (II). Designation D.1783–1791.

[3] APHA (American Public Health Association).1998. Standard Methods for the Examination of Water and Wastewater, 20th edn. APHA, Washington DC;. Available: www.epa.state.oh.us/dsw/credibledata/references.aspx

[4] Bhatnagar A. 2007. Removal of bromophenol from water using industrial wastes as low cost adsorbents. J. Hazardous Materials.13:93-102.
[5] Bodalo A, Gomez JL, Gomez E, Bastida J, Maximo MF. 2006. Comparison of commercial peroxidases for removing phenol from water solutions, Chemosphere. 63, 626–632.
[6] Budavari S.1996. The merck index. An encyclopedia of chemicals, drugs and Biologicals. Whitehouse Station, NJ: Merck.
[7] Calace N, Nardi E, Petronio BM, Pitroletti M, 2002 Adsorption of phenols by papermill sludges. Environ. Pollut. 118, 315-319.
[8] Dabrowski A, Podkoscielny P, Hubicki Z, Barczak M, 2005. Adsorption of phenolic compounds by activated carbon-a critical review. Chemosphere. 58, 1049-1070.
[9] Drinking Water Directive 80/778/EEC, Commission of the European Communities; 1980. Available: faolex.fao.org/cgibin/faolex.exe?rec_id=02960115. Ministry Ordinance No.
[10] Kennedy LJ, Vijaya JJ, Kayalvizhi K, Sekaran G, (2007). Adsorption of phenol from aqueous solutions using mesoporous carbon prepared by two-stage process. Chem. Eng. J. 132, 279–287.
[11] Kermani M, Pourmoghaddas H, Bina B, Khazaei Z, 2006. Removal of phenol from aqueous solutions by rice husk ash and activated carbon. Pakistan J. Biological Sci. 9, 1905-1910.
[12] Laszlo Z, Hodur C. 2007. Purification of thermal wastewater by membrane separation and ozonation. Desalination. 206, 333–34.
[13] Loreta Vallaja. 2011. Spectrophotometric determination of phenol in water. J Int Environmental Application and Science. 6(5):738-742.
[14] Michael K. Sofoniou, George A. Zachariadis, Aristidis N. Anthemidis, The mistoclis A. Kouimtzis. 2000. Spectrophotometric determination of phenols and cyanide after distillation from Natural waters. Intern J Environ Anal Chem. 78(3-4):353365.
[15] Ministry of Health, Labour and Welfare, Tokyo, Japan; 2000. Available: www.dionex.com
[16] Skoog DA, West DM, Holler FJ, Crouch SR. Fundamentals of analytical chemistry. 8th edition. 2004. Published by Brooks/Cole, a part of Cengage Learning. New Delhi110092. 214 – 215.
[17] U.S. Environmental Protection Agency. 2007. Current National Recommended Water. Quality. Criteria.. Available:http://www.epa.gov/waterscience/criteria/wqcriteria.html
[18] U.S Department of Health and Human Services (U.S.D.H.H.S. 2009. How can Phenol Affect my Health. Toxicology Profile for Phenol;. Available: en.m.wikipedia.org/wik/phenol
[19] Warner MA, Harper JV. 1985. Cardiac dysrhythmia associated with chemical peeling with phenol. Anesthesiology.62(3):366-7. DOI:10.1097/00000542198503000-00030.PMID 2579602.
[20] Westgard JO, Barry, PL, Quam EF. 1998. Basic QC practices: Training in statistical quality control for healthcare laboratories. Madison, WI: Westgard Quality Corporation; Available:www.clinchem.org/content/45/6/912