

# Solid phase extraction method for the determination of lead, nickel, copper and manganese by flame atomic absorption spectrometry using sodium bispiperdine-1,1'-carbottetrathioate (Na-BPCTT) in water samples

D. Rekha<sup>b</sup>, K. Suvardhan<sup>b</sup>, J. Dilip Kumar<sup>b</sup>, P. Subramanyam<sup>b</sup>, P. Reddy Prasad<sup>a</sup>,  
Y. Lingappa<sup>a</sup>, P. Chiranjeevi<sup>b,\*</sup>

<sup>a</sup> Department of Chemistry, Yogivemana University, Kadapa, India

<sup>b</sup> Environmental Monitoring Laboratory, Department of Chemistry, S.V. University, Tirumati-515002, AP, India

Received 7 October 2006; received in revised form 29 November 2006; accepted 30 November 2006

Available online 6 December 2006

## Abstract

A novel column solid phase extraction procedure was developed for the determination of lead, nickel, copper and manganese in various water samples by flame atomic absorption spectrometry (FAAS) after preconcentration on sodium bispiperdine-1,1'-carbottetrathioate (Na-BPCTT) supported by Amberlite XAD-7. The sorbed element was subsequently eluted with 1 M nitric acid and the acid eluates are analysed by Flame atomic absorption spectrometry (FAAS). Various parameters such as pH, amount of adsorbent, eluent type and volume, flow-rate of the sample solution, volume of the sample solution and matrix interference effect on the retention of the metal ions have been studied. The optimum pH for the sorption of above mentioned metal ions was about  $6.0 \pm 0.2$ . The loading capacity of adsorbent for Pb, Cu, Ni and Mn were found to be 28, 26, 22 and  $20 \times 10^{-6}$  g/mL, respectively. The recoveries of lead, copper, nickel and manganese under optimum conditions were found to be 96.7–99.2 at the 95% confident level. The limit of detection was  $3.6 \times 10^{-6}$ ,  $2.8 \times 10^{-6}$  and  $3.6 \times 10^{-6}$  g/mL for lead, copper, nickel and manganese, respectively by applying a preconcentration factor 50. The proposed enrichment method was applied for metal ions in various water samples. The results were obtained are good agreement with reported method.

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**Keywords:** Preconcentration; Solid phase extraction (SPE); Sodium bispiperdine-1,1'-carbottetrathioate (Na-BPCTT); Amberlite XAD-7; Flame atomic absorption spectrometry (FAAS); Water samples

## 1. Introduction

Trace metal analysis is an important part of studies in analytical chemistry in order to prevent the interference effect of matrix and to determine the low levels of trace metal ions in the water samples by flame atomic absorption spectrometry usually require an efficient preconcentration step in order to bring the concentration of the analyte within the dynamic measuring range of the detection limit. The separation enrichment techniques have been used to improve the sensitivity and selectivity of the trace analysis of the metal ions. Few methods including cloud point extraction [1–3] solvent extraction [4], co precipitation [5,6] membrane filtration [7], etc have been reviewed

for the enrichment of heavy metal ions in-off line or on-line performance. The above reported methods suffer from several disadvantages like poor sensitivity, provide low detection limit and also helps to avoid matrix interference in the analysis of the real samples.

Solid phase extraction based on the adsorption is also one of the important preconcentration methodologies [8–15]. It has some advantages including short analysis time, high preconcentration factors, low consumption of the organic solvent. In the solid phase extraction of the metal ions various adsorbents such as Amberlite resins [8,10–14] molten naphthalene [15] chromosorb resins [16,17] activated carbons [18–20] silica gel [21–24] were employed for the separation and preconcentration of the metal ion in the various environmental samples.

Chelating reagents like ammonium pyrrolidine dithiocarbamates (APPC) and sodium diethyl dithiocarbamates (NaDDC) are generally used for complexation and extraction in to organic

\* Corresponding author. Tel.: +91 877 2250556; fax: +91 877 2261274.  
E-mail address: [chiranjeevi.sai@yahoo.co.in](mailto:chiranjeevi.sai@yahoo.co.in) (P. Chiranjeevi).

solvent. Uses of APDC and NaDDC have certain disadvantages like poor sensitivity, less stability and low recoveries.

In view of this authors have reported, a facile, simple and novel method for the column separation and preconcentration technique for the determination of lead, nickel, copper and manganese from various water samples. The column loaded with Amberlite XAD-7 supported impregnated with sodium bispiperidine-1,1'-carbotetrathioate (Na-BPCTT). The sorbed elements were sequentially eluted with 1 M nitric acid. The acid eluates were further analysed by FAAS. Optimum experimental conditions were investigated with respect to a standard solution of the same matrix, in order to examine the possibility of obtaining the maximum extraction efficiency with minor sample treatment and minimal experimental conditions. Under these conditions, preconcentration factor of 40–60 was achieved.

## 2. Experimental

### 2.1. Instrumentation

A Perkin-Elmer @ Model 2380 atomic absorption spectrometry (AAS) with air-acetylene flame and hollow cathode lamps were used for the analysis of lead, copper, nickel and manganese. All instrumental settings were those recommended in the manufacturer's manual book and the instrumental conditions were shown in Table 8. A pH meter, Elico Li-129 Model glass-electrode was employed for measuring pH values.

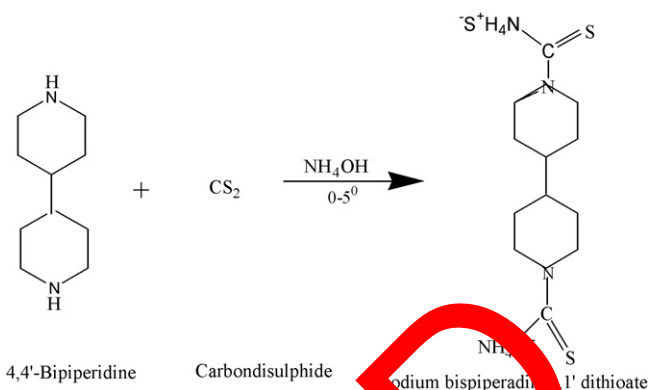
### 2.2. Reagents and standard solution

Doubly distilled water and highly purity reagents were used for all preparations of the standard and samples solution. All the chemicals were purchased from Merck Chemicals, Mumbai, India. Standard stock solutions (1000 µg/L) of Pb, Ni, Cu and Mn were prepared by dissolving the proper amounts of analyte in doubly distilled water in a 100 mL flask. Dilute solutions were prepared by the appropriate dilution of the stock solution daily in doubly distilled water for reference solutions. The pH adjustment was made by adding 2 mL of phosphate buffer solution.

Buffer solution of pH 6.0 ± 0.2 was prepared by adding concentrated sulphuric acid (7.0 mL) to 250 mL distilled water in a 500 mL flask. Then monosodium dihydrogen phosphate monohydrate (20 g) was added and the flask shaken until dissolution was completed. The solution was then diluted to 500 mL. It was stored in a clean metal free polyethylene bottle. Sodium bispiperidine-1,1'-carbotetrathioate (Na-BPCTT) solution (0.01%) was prepared by dissolving 0.01 g of the reagent in 100 mL of doubly deionized distilled water. Synthesis of (Na-BPCTT) is shown in Scheme 1.

### 2.3. Column preparation

0.2–0.6 g of Amberlite XAD-7 loaded with sodium bispiperidine-1,1'-carbotetrathioate (Na-BPCTT) was packed in a glass column having stopcock and a porous disk, was 10 cm long and 1.0 cm internal diameter. A small amount of glass wool



Scheme 1. Synthesis of sodium bispiperidine-1,1'-dithioate (Na-BPCTT).

was placed on the disk to prevent disturbing of the XAD-7-reagent resin beds during the sample loading. The bed height of the resin in column was approximately 20 mm. The column was conditioned with 10 mL HCl solution and doubly distilled water. Then the column was conditioned to studied pH by passing an aqueous solution of HCl or NH<sub>3</sub> having the same pH as that of sample solution through the column, prior to passage of the sample solution.

### 2.4. Procedure

An on-line column procedure was applied for the preconcentration. An aliquot of the sample solution (500 mL) containing 25 µg of lead, 20 µg copper, 15 µg nickel and 10 µg manganese was taken and pH was adjusted to the 6.0 ± 0.2 with phosphate buffer. The resulting solution was passed through the column at flow rate of 2 mL/min experimentally. The retained metal ions were eluted from the solid phase with a suitable eluent determined experimentally. The concentrations of the metal ions were determined by flame atomic absorption spectroscopy.

### 2.5. Analysis of trace metal ions in water samples

The spiked water samples were prepared with 2 L of distilled water by adding known amounts of analyte ions, preconcentrated and determined by the standard procedure discussed earlier and percentage recoveries of analyte ions were presented in Table 5.

The water samples which is collected from different places (in and around Tirupati) analysed was filtered through a cellulose membrane filter of pore size 0.45 µm. The pH of 500 mL of the sample was adjusted to 6.0 ± 0.2. Then the reagent solution was added. The sample was passed through the column at the flow rate of 2 mL/min. The column was then washed with 5 mL of doubly deionized distilled water. The sorbed metal ions were eluted with 10 mL of 1 M HNO<sub>3</sub> after 2 mL of doubly distilled water added through the sorbent and determined as described in general procedure and the results were shown in the Table 6.

## 3. Result and discussion

Sodium bispiperidine-1,1'-carbotetrathioate (Na-BPCTT) is a sensitive, selective and specific complexing ligand for ana-

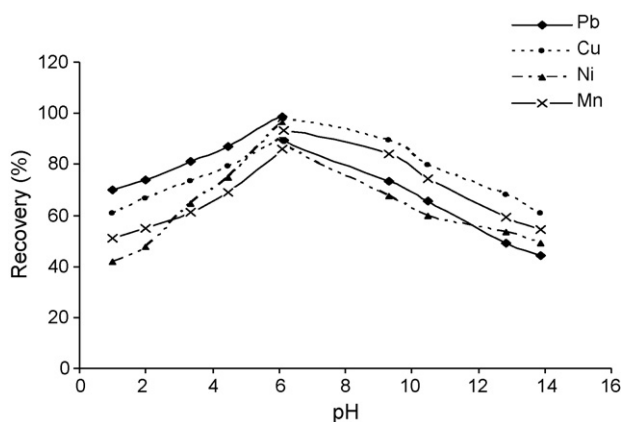


Fig. 1. Effect of pH on the complexation of metal with BPCTT.

lytical determination of analyte ions (lead, copper, nickel and manganese) at  $\text{pH } 6.0 \pm 0.2$ . Crystallization of water is less in sodium bis(2-piperidinyl)thiocarbamate (Na-BPCTT) when compared with other dithiocarbamate, therefore the extractability of the complex become easier. The metal salt of this reagent is a resonance hybrid of the structures which contributed to stability of metal complexes. This proposed method was employed for different natural water samples collected from Swarnamukhi river belt (Chandragiri), Kalyanidam reservoir and Ghajulamandayam area. The accuracy of the method was ascertained by comparing the results with reported method [26] and the results were shown in the Table 5.

### 3.1. Effect of the pH

The pH of the sample solution plays an important role in the ability of the column containing sodium bis(2-piperidinyl)-1,1'-carbottetrathioate (Na-BPCTT) on Amberlite XAD-7 to preconcentrate the metal ions (lead, copper, nickel and manganese) was studied. For that purpose, a lot of solutions (500 mL) each containing one of the four metal ions (lead, copper, nickel and manganese) at a concentration given in the general procedure, was taken. The pH value of the sample solutions was adjusted to a range of 1–7 with phosphate buffer. The obtained solutions were passed through the column at a flow rate at about 2 mL/min. The metal ions were then eluted by an appropriate eluent and determined by FAAS. In all cases, metal retention by the reagent increased with increasing pH and reached a maximum ( $\text{pH } 6.0 \pm 0.2$ ) after which the retention decreased. So  $\text{pH } 6.0 \pm 0.2$  was the optimum pH chosen for the further studies and graphically represented in Fig. 1 and data was shown in Table 1.

### 3.2. Effect of the flow rates of sample solution

The retention of an element on an adsorbent also depends on the flow rate of the sample solution. Therefore, the effect of the flow rate of the sample solution on the recovery of the metal ions was investigated under the optimum conditions (pH, eluent type, etc.). The sample solution was passed through the column with the flow rates adjusted in a range of 0.5–5 mL/min by gravity.

Table 1

Effect of pH on the complexation of metal ions with sodium bis(2-piperidinyl)-1,1'-carbottetrathioate (Na-BPCTT)

pH	Recovery (%) <sup>a</sup>			
	Pb	Cu	Ni	Mn
2.0	81.8 ± 0.05	78.1 ± 0.02	81.4 ± 0.03	83.3 ± 0.04
3.0	88.5 ± 0.09	89.1 ± 0.04	88.2 ± 0.03	95.4 ± 0.05
4.0	95.3 ± 0.05	94.8 ± 0.04	92.3 ± 0.04	96.1 ± 0.09
5.0	96.1 ± 0.04	98.6 ± 0.16	98.8 ± 0.07	96.3 ± 0.11
6.0	98.1 ± 0.05	99.1 ± 0.08	99.8 ± 0.16	98.3 ± 0.04
7.0	95.2 ± 0.06	97.1 ± 0.29	98.4 ± 0.09	97.2 ± 0.08

<sup>a</sup> Mean ± standard deviation ( $N=5$ ).

As can be seen in Fig. 2, at flow rate greater than 3 mL/min, there was a decrease in the recovery of lead, copper nickel and manganese. The reason for this decrease is probably insufficient contact of the metal ions and the adsorbent to reach equilibrium. Therefore, a flow rate of 2 mL/min was applied for lead, copper, nickel and manganese in throughout the experiments. The flow rate of the elution solution was 2 mL/min.

### 3.3. Effect of the amount of adsorbent (bed height)

The retention of the metal ions was examined in relation to the amount of adsorbent, which was varied from 200 to 600 mg. It was found that the recoveries of lead, copper, nickel and manganese were gradually increased up to 500 mg of the adsorbent. Therefore, 500 mg of the adsorbent was used for lead, copper, nickel and manganese.

### 3.4. Effect of the type and volume of elution solutions

The other important factor that affects the preconcentration procedure is the type, volume and concentration of the eluent used for the removal of metal ions from the sorbent. Optimization of the elution conditions was performed in order to obtain the maximum recovery with the minimal concentration and volume of the elution solution. The different concentrations of nitric acid hydrochloric acid and sulphuric acid were tested to remove the bound metal ions from the sorbent, 10 mL of 1 M  $\text{HNO}_3$  solution was found to be satisfactory (recovery >95%) for lead,

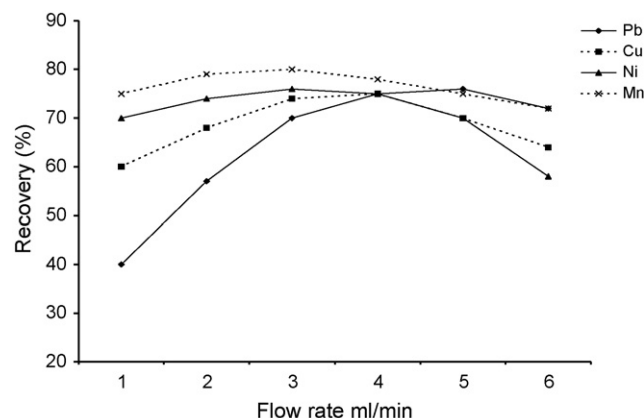


Fig. 2. Effect of flow rate of sample volume on retention of analyte ions.

Table 2  
Effect of sample volume on elution of metal ions

Volume of sample (mL)	Recovery (%) <sup>a</sup>			
	Pb	Cu	Ni	Mn
100	96.0 ± 0.03	96.1 ± 0.05	96.1 ± 0.02	98.8 ± 0.09
250	96.2 ± 0.04	96.4 ± 0.04	97.1 ± 0.29	98.2 ± 0.35
500	99.1 ± 0.07	99.4 ± 0.07	98.2 ± 0.09	99.6 ± 0.07
750	97.8 ± 0.29	98.1 ± 0.09	99.1 ± 0.32	97.5 ± 0.25
1000	98.1 ± 0.17	99.1 ± 0.07	98.9 ± 0.14	98.6 ± 0.16

<sup>a</sup> Mean ± standard deviation ( $N=5$ ).

copper, nickel and manganese and the results were shown in Table 3.

### 3.5. Effect of the sample volume

The effect of sample volume on the elution of lead, copper, nickel and manganese was studied by taking different volumes of the water samples in the range of 100, 250, 500, 750 and 1000 mL. The extraction was carried out as described in general procedure and the results are reported in the Table 3. In all cases the recovery obtained was higher than 96.0% for these elements. However, the efficiency of the recovery slightly decreased when sample volume was more than 500 mL. Hence, 500 mL water sample was chosen for the present study and the results are shown in Table 2.

### 3.6. Effect of interfering ions

The interference of co-existing ions on the determination of lead, copper, nickel and manganese was investigated. A solution (500 mL) containing 50, 50, 100 and 150 × 10<sup>-6</sup> g/mL of lead, copper, nickel and manganese, respectively and various amounts of foreign ions were prepared and procedure described in the

Table 3  
Recovery of trace metals (Pb, Cu, Ni and Mn) using various eluents

Eluents	Recovery (%)			
	Pb	Ni	Cu	Mn
0.5 M HCl	96.0 ± 0.09	96.5 ± 0.05	95.5 ± 0.06	95.3 ± 0.08
1.0 M HCl	96.2 ± 0.08	96.3 ± 0.04	97.5 ± 0.08	97.5 ± 0.05
0.5 M H <sub>2</sub> SO <sub>4</sub>	96.5 ± 0.04	96.8 ± 0.06	97.2 ± 0.08	97.2 ± 0.08
1.0 M H <sub>2</sub> SO <sub>4</sub>	97.8 ± 0.04	97.5 ± 0.04	97.9 ± 0.04	98.1 ± 0.05
0.5 M HNO <sub>3</sub>	98.1 ± 0.04	98.9 ± 0.05	98.8 ± 0.05	99.7 ± 0.04
1.0 M HNO <sub>3</sub>	98.1 ± 0.09	99.1 ± 0.08	99.1 ± 0.03	99.8 ± 0.06

<sup>a</sup> Mean ± standard deviation ( $N=5$ ).

Table 4  
The effect of interfering ions on the recovery of 50, 50, 100, 150 μg mL<sup>-1</sup> of Pb, Cu, Ni and Mn

Interfering ions	Concentration of interfering ions (× 10 <sup>-6</sup> g/L)	Recovery (%) <sup>a</sup>			
		Pb	Cu	Ni	Mn
Cd <sup>2+</sup>	1000	99.5 ± 0.1	101.0 ± 0.2	101.0 ± 0.1	99.0 ± 0.2
NH <sub>4</sub> <sup>+</sup> , K <sup>+</sup> , Mg <sup>2+</sup> , Li <sup>+</sup> , Cl <sup>-</sup> , NO <sub>2</sub> <sup>-</sup> , SCN <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup>	150	99.8 ± 0.2	99.5 ± 0.1	99.0 ± 0.3	99.9 ± 0.3
Hg <sup>2+</sup> , Zn <sup>2+</sup> , Cr <sup>3+</sup> , Ca <sup>2+</sup> , Se <sup>+4</sup> , F <sup>-b</sup> , Al <sup>3+</sup>	50	100.0 ± 0.1	99.8 ± 0.2	98.5 ± 0.1	100.0 ± 0.1

<sup>a</sup>  $x \pm st\sqrt{n}$  at 95% confidence ( $n=5$ ).

<sup>b</sup> Masked by NaBH<sub>4</sub>.

experimental part was applied. The deviation of ±2% or more from the absorbance value of the standard solution was taken as interference. The results were shown in the Table 4. It can be seen that a very good selectivity is achieved.

### 3.7. Preconcentration time

The effect of preconcentration time on integrated absorbance of analyte ions (lead, copper, nickel and manganese) were investigated in the range of 200–300 s, at a sample loading rate of 2 mL/min. It is evident for the increase of preconcentration time causes an increase of integrated absorbance of analytes. It is very difficult for the PCC (Preconcentration column) to be eluted. Therefore the loading time was selected as 250 s for thought the experiments.

### 3.8. Effect of column reuse

In order to examine the long-term stability of the reagent, it was subjected to successive adsorption and desorption cycles (5 runs in a day and the next 5 runs 1-day later, and so on, total 10 runs) by passing 500 mL of metal solutions through the column. The stability and potential recyclability of the column-containing reagent were assessed by monitoring the change in the recoveries of the analytes. After 10 runs, the recoveries of all of the analytes slightly decreased to below 95%.

### 3.9. Loading capacity

The loading capacity of sodium bispiperidine-1,1'-carbottetrathioate (Na-BPCTT) immobilized on Amberlite XAD-7 was evaluated from the breakthrough curve plot by a method given by Bag et al. [30]. The capacities were found as to be 28, 26, 22 and 20 × 10<sup>-6</sup> g/mL for lead, copper, nickel and manganese when using sodium bispiperidine-1,1'-carbottetrathioate (Na-BPCTT) and 18, 16, 14 and 12 × 10<sup>-6</sup> g/mL with out using sodium bispiperidine-1,1'-carbottetrathioate (Na-BPCTT), respectively.

### 3.10. Lower limit of detection

The detection of lower limits for any newly developed method shows the degree of sensitivity and selectivity of the analytes extraction. For the purpose were performed by passing the 500 mL sample solution through the preconditioned resin bed, containing metal ions in the range of 3–30 × 10<sup>-6</sup> g/mL for the

Table 5  
Recovery of trace metals from spiked water sample

Elements	Proposed method (concentration added)									Reported method [26]		
	$10 \times 10^{-6}$ g/L			$15 \times 10^{-6}$ g/L			$25 \times 10^{-6}$ g/L			Recovery (%) <sup>a</sup>		
	Recovery (%) <sup>a</sup>	<i>t</i> -Test	<i>f</i> -Test	Recovery (%) <sup>a</sup>	<i>t</i> -Test	<i>f</i> -Test	Recovery (%) <sup>a</sup>	<i>t</i> -Test	<i>f</i> -Test	$10 \times 10^{-6}$ g/L	$15 \times 10^{-6}$ g/L	$25 \times 10^{-6}$ g/L
Pb	98.3 ± 0.09	4.89	0.13	97.3 ± 0.21	1.38	0.41	98.5 ± 0.08	0.10	0.01	93.2 ± 0.03	97.1 ± 0.13	98.0 ± 0.53
Cu	97.6 ± 0.29	3.83	0.07	97.5 ± 0.55	1.49	0.11	99.2 ± 0.07	0.16	0.79	93.5 ± 0.08	96.1 ± 0.08	98.4 ± 0.17
Ni	96.9 ± 0.04	3.84	0.26	96.7 ± 0.0.11	1.44	0.27	98.5 ± 0.09	1.30	0.32	92.9 ± 0.04	95.1 ± 0.06	97.0 ± 0.07
Mn	98.6 ± 0.16	4.53	0.69	98.6 ± 0.36	2.94	0.36	97.5 ± 0.08	0.10	0.83	93.9 ± 0.08	95.5 ± 0.06	98.2 ± 0.3

<sup>a</sup> Mean ± standard deviation (*N*=5).

Table 6  
Determination of trace metal ions in various water samples

Elements	Proposed method					Recovery (%) <sup>a</sup>
	River water		Tap water			
	Added	Found ( $\times 10^{-6}$ g/L)	Recovery (%) <sup>a</sup>	Found ( $\times 10^{-6}$ g/L)	Recovery (%) <sup>a</sup>	
Pb	5	4.8	98.0 ± 0.01	4.95	99.0 ± 0.02	99.0 ± 0.02
	10	9.8	98.0 ± 0.02	9.9	99.0 ± 0.05	99.0 ± 0.05
	20	19.8	99.5 ± 0.03	19.8	99.5 ± 0.06	99.0 ± 0.06
Cu	5	4.95	99.0 ± 0.02	5.2	104.0 ± 0.02	104.0 ± 0.02
	10	9.7	99.0 ± 0.06	9.9	99.0 ± 0.01	99.0 ± 0.01
	20	19.9	99.0 ± 0.05	19.9	99.5 ± 0.08	99.5 ± 0.08
Ni	5	4.9	98.0 ± 0.01	5.1	102.0 ± 0.05	102.0 ± 0.05
	10	9.8	98.0 ± 0.07	9.95	99.5 ± 0.05	99.5 ± 0.05
	20	19.9	99.0 ± 0.04	19.6	98.5 ± 0.03	98.5 ± 0.03
Mn	5	4.9	98.0 ± 0.03	4.95	99.0 ± 0.04	99.0 ± 0.04
	10	9.9	98.0 ± 0.05	9.95	99.5 ± 0.05	99.5 ± 0.05
	20	19.9	99.5 ± 0.02	19.9	99.5 ± 0.02	99.5 ± 0.02

<sup>a</sup> Mean ± standard deviation (*N*=5).

proposed method, a detection limit was found to be 0.17, 0.83 and  $3.6 \times 10^{-6}$  g/mL for analyte ions (lead, copper, nickel and manganese) was achieved.

### 3.11. Analytical features

The analytical features of the proposed method such as precision, linear range, calibration curve, limit of detection were

also examined. Precision of the method were estimated by applying successive retention and elution cycles with 500 mL of a sample solution containing 25 µg of lead, 20 µg of copper, 15 µg nickel and 10 µg of manganese under the optimum conditions, mentioned above. The recoveries of lead, copper, nickel and manganese were quantitative (>95%) and the precision of the method was very good (R.S.D. < 3%) for sodium bispiperdine-1,1'-carbotetrathioate (Na-BPCTT) on Amberlite XAD-7. The

Table 7  
Comparison of reported method with present method for determination of trace metals

Complexing reagent	Detection limits ( $\times 10^{-6}$ g/L)	Remarks	Reference
Phenylpiperidine dithiocarbamate	17	Low detection limit, commercial reagent, less sensitivity	[18]
Ammonium pyrrolidone dithiocarbamate	0.83	Low detection limit, high reagent consumption, instability of the complex	[25]
Piperidine dithiocarbamate	25	It is a column technique and needs elaborated procedure, time consuming, risk of contamination	[26]
Ammonium hexamethylene dithiocarbamate	15	Low sensitivity and selectivity	[27]
Potassium propyl xanthate	10	Low detection limit, $\text{PO}_4^{3-}$ , $\text{Mn}^{2+}$ , and $\text{Fe}^{3+}$ interferes seriously	[28]
Potassium ethyl xanthate	12	Less sensitive and suffers from interference effect	[29]
Sodium bispiperdine-1,1'-carbotetrathioate (Na-BPCTT)	3.6, 3.2, 3.0, 3.6	Sensitive, selective, facile, economical reagent, free from interference and contamination	This work



Table 8  
FAAS instrumental conditions employed to determination of metal ions

Flame type	Air acetylene
Air flow rate	11.00 L min <sup>-1</sup>
Acetylene flow rate	0.50 L min <sup>-1</sup>
Slit width	0.7 nm
Lamp current	5 mA
Burner height	13 mm
Integration time	5 S

recoveries and the precision found by using Amberlite XAD-7 as adsorbent alone were very low (below 70%). The linear calibration ranges for measurements under the optimum conditions were  $4.0\text{--}8.0 \times 10^{-6}$  g/mL for lead, copper, nickel and manganese. The detection limits based on three-times the standard deviation of the blank solution were found to be 3.6, 3.0, 2.8 and  $3.6 \times 10^{-6}$  g/mL detection limit for lead, copper, nickel and manganese, respectively.

### 3.12. Application of proposed method for the determination of trace metals with reported method

In order to check the applicability of the proposed method in various water samples, lead, copper, nickel and manganese were determined in a water sample collected in and around Tirupati an appropriate volume of sample solutions was adjusted to the optimum pH and subjected to the recommended column procedure for the preconcentration and determination of metal ions. The results reported in Tables 5 and 6 with a confidence interval for the 95% confidence level show the applicability of the proposed method to water analysis. The analytes were determined with a relative error lower than 10% in all samples.

It is evident from the data in Table 7 that the proposed method is rapid and more sensitive.

## 4. Conclusion

The results presented in this paper demonstrate the usability of a sorbent sodium bisphosphate-1,1'-carbottetrathioate (Na-BPCTT), for the preconcentration of trace metal ions. The ability of sodium bisphosphate-1,1'-carbottetrathioate (Na-BPCTT) for selective sorption of trace metals from aqueous solution was

confirmed. The proposed procedure provides a simple, sensitive, precise, reliable and accurate technique for the preconcentration and determination of lead, copper, nickel and manganese. The recoveries of analytes studied were nearly quantitative (>95%). The accuracy of the results was verified by analyzing the spiked water samples and the results were shown in the Table 5. The recoveries for these elements were very satisfactory and it is evident for the reliability of the proposed method for the analysis of water samples.

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