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A SIMPLE SPECTROPHOTOMETRIC DETERMINATION OF LEAD IN MEDICINAL LEAF AND ENVIRONMENTAL SAMPLES USING SCHIFF BASE LIGAND

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ABSTRACT

A simple, rapid and sensitive spectrophotometric method is developed for the determination of Pb (II) using 2, 4–Dihydroxy benzophenone-2-Amino thiophenol (BPBT) as an analytical reagent. The reagent has been synthesized and characterized using IR, ^{1}H NMR and Mass spectral data. The metal ion in aqueous medium, forms light yellow colored complex with BPBT at pH = 9.0 (ammonium chloride – ammonium hydroxide) performance utmost absorbance at 347 nm. Thus, analytical studies are more carried out at 347 nm. The reagent BPBT reacts with lead (II) metal ion in acidic medium to provide light yellow colored 1:1 (M:L) metal ligand complex. The color metal ligand complex reactions were instantaneous and absorbance values remain constant for 24 hours. The stoichiometric composition of the metal ligand complex is studied with the Job's continuous variation and molar ratio methods. The Beer's law is obeyed in the range of 0.27-2.4 µg ml^{-1}of metal ion. The molar absorptivity and sandell's sensitivity of the metal complex are found to be 5.59 x 10 ^{4} Lmol^{-1}cm^{-1} and 0.00178 µg/ cm^{-2} respectively. Since BPBT ligand method is more sensitive, it is applied for the determination of lead in medicinal leaf and environmental samples.

KEYWORDS: Spectrophotometry, Lead (II) determination, 2,4–Dihydroxy benzophenone-2-Amino thiophenol (BPBT), Medicinal leaf and Environmental samples.

1. INTRODUCTION

Lead is accumulative poison that enters the body from lead water pipes, lead-based paints and leaded petrol (Renner, R. 1995).[1] Presence of even traces of Pb (II) in environmental samples leads to many fatal diseases including dysfunction of renal blood and neurological systems and environmental pollution. The Pb (II) easily gets deposit in blood, kidney, reproductive system, nervous system, brain and acute lead poisoning can result in colic shock, severe anemia and irreversible brain damage. Lead compounds as antiknocking agents in automobile fuels cause air pollution.

The determination of trace amounts of lead is very important in the context of environmental monitoring. However a large number of spectrometric methods for determination of lead are reported facing interference due to the presence of several metal ions.[2-8] The present study is planned to determine the prevalence of selected trace elements in medicinal leaf and environmental samples.

Medicinal plants are starting material for any herbal preparation such as herbal medicines, herbal teas and herbal oil etc. These preparations are being used worldwide due to their therapeutic potential and as they are considered to be safe compared to allopathic medicines. Lead is the most common toxic metal that has become a matter of concern due to the reports of their contamination in various herbal preparations and herbal ingredients.[9-14] Lead is known to cause neurological disorders, anemia, kidney damage, miscarriage, lower sperm count and hepatotoxicity in higher concentration.[15-16]

Ocimum sanctum is a well-known traditional plant used in Ayurvedic system of medicine.[17] Amongst the indigenous herbals of India, several therapeutic properties have been attributed to O. sanctum-a Medhya rasayanas.

The essential oils from Ocimum contain many terpenes (linalool, citral, 1, 8-cineole) and phenylpropanoids (e.g. methyl chavicol, eugenol) produced in specialized glandular trichomes.[18] Presence of eugenol is attributed to its anti-oxidative property and is also thought to be responsible for inhibition of lipid per oxidation.[19] This property helps in maintaining good health and in preventing the chance occurrence of heart diseases as well as most of the other biochemical diseases because of oxidative stress which being the hallmark of such diseases.[20] In addition, available literature data indicates

that there is a great deal of diversity in the composition of essential oil of Ocimum sanctum cultivated in different localities.[21]

The ICP-OES technique is used which converts all Pb (II) metal ions into the inorganic lead forms. The ICP-OES and ICP-MS methods are very probable techniques for quantitative determination of the Pb (II) metal ion. For the most part the significant advantages of these two ICP-OES and ICP-MS techniques are high sample throughput, simplicity and good sensitivity in similarity to other techniques[22-23] used for Pb (II) metal ion determination.

At the current time, owing to the superior kindliness achieved with axially viewed plasma and improved spectral decision prearranged by elevated decision monochromators, it is conventional to facilitate little attentions of every of course happening lead perhaps directly considered by ICP-OES technique. Moreover, depending taking place the nebulizer used to introduce the sample outcome in the plasma.

This object describe synthesis, characterization and investigative properties of novel reagent viz., 2,4–Dihydroxy benzophenone-2-amino thiophenol (BPBT) reacts with metal ion. Because the reagent BPBT is more sensitive, hence it is used for the spectrophotometric determination of lead (II) in various soil, water and medicinal leaf samples.

2. Experimental

2.1. Equipment

A Schimadzu UV-Visible spectrophotometer Model-1601 (PerkinElmer Singapore Private Limited, Singapore) equipped with 10 cm quartz cell and ELICO model L1-610 pH meter (M/s ELICO private limited, Hyderabad, India) are used in the current analysis. The Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES, Model-7000) method is used for the quantitative determination of Pb (II) metal ion and also AOAC methods are used (AOAC 1986, 2003; Jorhem 1993). In this Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) method, the samples are dissolved at 190°C and 400 psi pressure in Mars 5 apparatus (Vessel Type XKP 1500, CEM, Matthews, USA). The Lead (II) metal ion is analyzed by ICP-OES (Varian Vista-MPX CCD Simultaneous Spectrophotometer, Mugrave-Victoria, Australia).[24, 25]

2.2 Reagent and solutions

The entire chemicals are used investigative reagent (AR) status of the uppermost cleanness accessible procured from Merck, throughout the investigation doubly distilled de-ionized water is used. The glass vessels are cleaned drenched in acidified solvents of $K_2Cr_2O_7$ pursued by swabbing with con. HNO_3 and are bathed a quantity of epochs with high cleanliness double distilled water and acetone. The stock aliquot solutions, environmental and medicinal leaf sample solutions are held in reserve in polypropylene bottle containing 1ml of Conc. HNO_3 solution.

2.2.1. Preparation of ligand (BPBT)

The reagent is prepared by using 2,4-Dihydroxybenzophenone (BP) (5 g, 0.0233 mol) dissolved in 20 ml of methanol and 2-aminothiophenol (BT) (2.5 ml, 0.0233 mol) dissolved in 20 ml of methanol are taken in 250 ml round bottom flask and then added appropriate quantity (10 ml) of 1M sodium acetate solution to the reaction mixture and then refluxed for 12 hours, on cooling the reaction mixture it gives brown colored product. Thus the result is collected by filtration and washed a number of times with hot water followed by n-hexane. This result is recrystallised from methanol and dried in vacuum, the ligand Yield is 8.48 g; m.p.118-120 ^{0}C. Thus the structure of BPBT is given away in the (Fig.1).

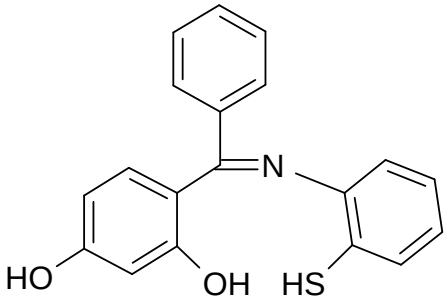

Fig.1: BPBT-Structure.

2.2.2. Characterization of reagent (BPBT)

The reagent has been characterized by IR, ^{1}HNMR and Mass spectral data. The IR spectrum of BPBT shows bands at 3374 (s), 3063 (m), 2593 (w),1628 (s),1598 (s) 1584 (s) ,1220 (s), 1122 (m), 699(δ)(delta) cm^{-1} in that order analogous to ν (O-H) symmetric stretch, ν(C-H) aromatic stretch (sp^2---C-H), ν(S-H) stretch (weak) (δ), ν(C = C) aromatic stretch, ν(C = N) schiff base, aromatic ring ν (C - C) stretch, ν(C - O) stretch, ν (C - N) stretch, ν(C - S) stretch is shown in the Fig.2. The H^{1}NMR (Proton) spectrum of BPBT ($CDCl_3$+DMSO-d_6) showed signals at 6.30 – 7.54 (12H), 3.30 (1H) due to Benzene (C_6H_5) or Aromatic protons, Thiolic protons (-SH) is shown in Fig.3. The Mass spectrum of BPBT shows signal at 322 (M+1) corresponding to its molecular ion peak is shown in the Fig.4. Hence, the molecular formula of the reagent is C_{19} $H_{15}NSO_2$ and the Molecular Weight of the reagent (m/z) is - 321.

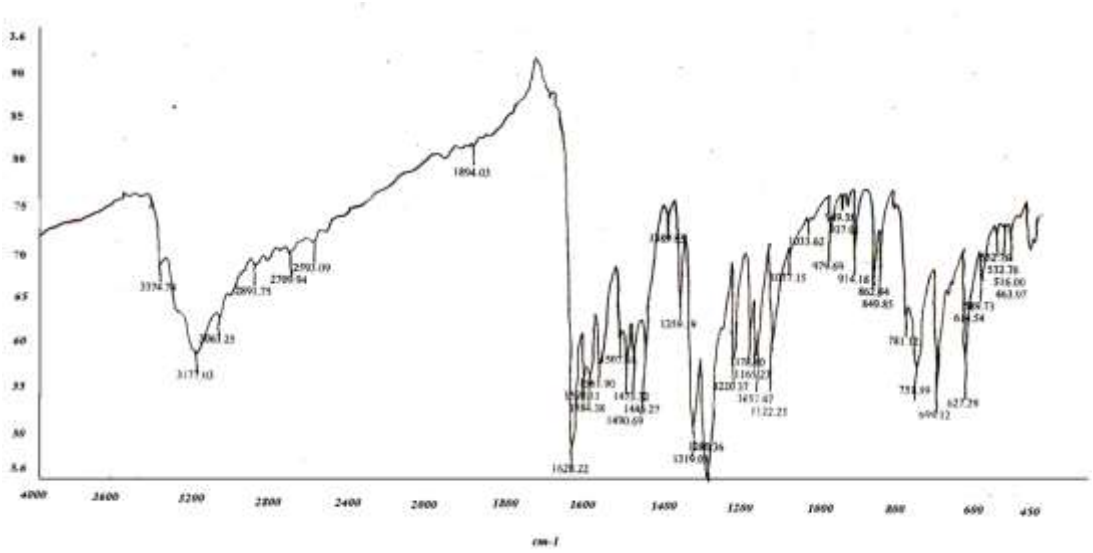

Fig. 2. Infrared spectrum of BPBT.

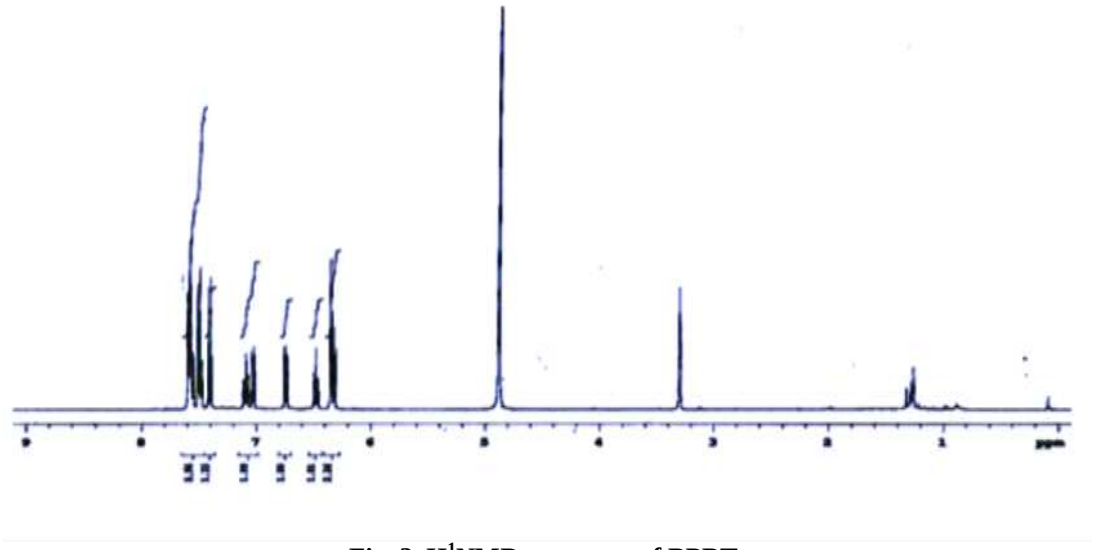

Fig. 3. H^1NMR spectrum of BPBT.

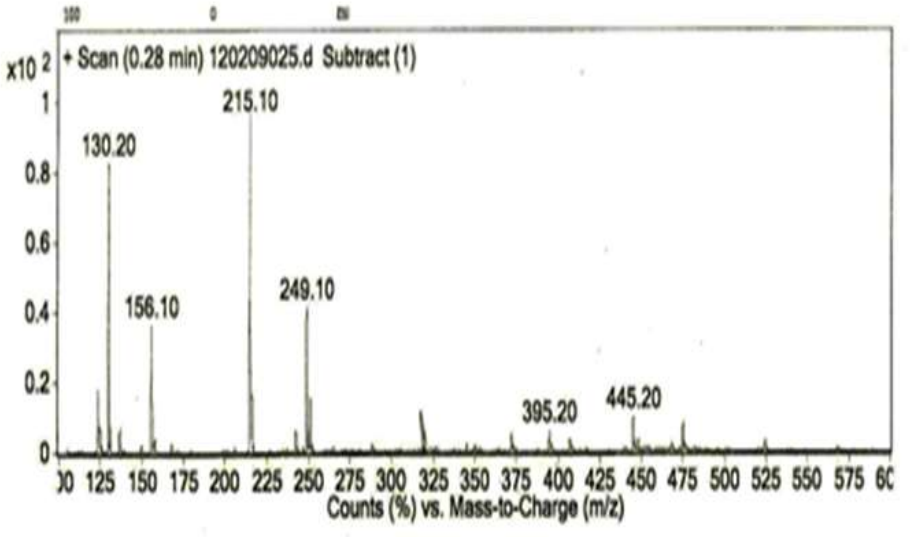

Fig. 4. Mass spectrum of BPBT.

2.2.3. pKa values of reagents (BPBT)
The reagent BPBT pKa standards are dogged by recording the UV-Visible spectroscopy of 1 x 10^{-4} M attention of the reagent BPBT solutions at diverse pH standards and by taking the reckoning mean of these standards obtained from the measurements at diverse wave lengths to dogged spectrophotometrically using Phillips and Merrit method. The standards of deprotonation obtained for the reagent (BPBT) are 6.86 (pK_1) and 6.86 (pK_2).

2.2.4. BPBT solution, 1 x 10^{-2} M
A 0.01M reagent solution is prepared by dissolving 0.3215 gm of BPBT in 100 ml of methanol. The reagent (BPBT) solution is stable for at least 24 h.

2.2.5. Pb (II) Standard solution
A 1 x 10^{-2} M lead stock solution was prepared by dissolving 0.3312 g of lead nitrate ($PbNO_3$) (Merck Darmstadt) in double distilled water containing few drops of conc. HNO_3 and diluted up to the mark in a 100 ml volumetric flask. 1000 ppm lead stock solution was prepared by dissolving 0.1598 gm of lead nitrate in 100 ml double distilled water.

2.2.6. Buffer Solution
1M Sodium acetate + 0.1M hydrochloric acid are used to prepared pH= 0.5 – 3.0 buffer solutions, 0.2M Sodium acetate + 0.2M acetic acid are used to prepared pH = 3.5 – 6.0 buffer solutions, 1M Sodium acetate + 0.2M acetic acid are used to prepared pH = 6.5 – 7.5 buffer solutions and 2M Ammonia + 2M ammonium chloride are used to prepared pH = 8.0 – 12.0 buffer solutions. Hence all the buffer solutions are prepared in double distilled water. Suitable portions of these solutions are mixed to get the desired pH.

2.2.7. Potassium permanganate solution
A 1% potassium permanganate solution is prepared by dissolving 1 gm of $KMnO_4$ in double distilled water. Aliquots of this solution are standardized with oxalic acid.

2.2.8. Tartrate solution
A 100 ml of tartate stock solution (0.01% w/v) is prepared by dissolving 10 mg of ACS grade (99%) potassium sodium tartrate tetrahydrate in 100 ml double distilled water.

2.2.9. Aqueous ammonia solution
A 100 ml aqueous ammonia solution is prepared by diluting 10 ml concentrated ammonia (NH_3) (28–30%, ACS grade) in to the 100 ml of double distilled water. Then the aqueous ammonia solution is stored in a polypropylene bottle.

2.3. Preparation of Samples
2.3.1. Preparation of aqueous solutions
Diverse aliquots of the sample solutions are collected from diverse places around Tirupati, A.P, and India. The collected aqueous sample solutions (150 ml) are preserved at 5^oC in metal free polyethylene bottles. The collected aqueous sample solutions are clean through what man no. 41 filter paper and transferred into the 250 ml beakers. Each and every one the filtered environmental water samples were evaporated nearly to dryness with a mixture of 10 ml con HNO_3 and 5 ml of con H_2SO_4 in a fume cupboard and after that cooled to the room temperature. Hence, the purified sample solutions are digested with the excess amount of potassium permanganate ($KMnO_4$) solvent according to the recommended method (Fifiled et al.,).[5] After that the aqueous residues are heated with the10 ml of double distilled water solution in order to melt the salts. Hence, the water residue is chilled and neutralized with dilute NH_4OH solvent. After that the digests are transferred into a 25 ml calibrated flasks and diluted up to the mark with double distilled water.

2.3.2 Soil samples
Preparation of the soil samples are carried out by microwave digestion. Approximately 1 g (dry mass) of soil samples are weighed directly in to the PTFE vessels to which 10 ml of conc. HNO_3 is added and the vessels are capped immediately. The digestion programme consists of a ramp time of 10 min tom reach 180^0 C. The power was 800 W. After the completion of program vessels are cooled ,vented and opened and then 2 ml of 30% H_2O_2 as added and filtered the solutions in 25 ml volumetric flasks and are made up with double distilled water. Blanks are prepared by following similar digestion procedure without soil sample.

2.3.3. Preparation of medicinal leaf samples
Sample preparation of the leaf samples are carried out by microwave digestion. Approximately 1 g (dry mass) of leaf sample materials are weighed directly in to the PTFE vessels, to which 10 ml of conc. HNO_3 is added and the vessels are capped immediately. The digestion programme consists of a ramp time of 10 min tom reach 150^0 C. The power is 800 W. After the completion of program vessels are cooled, vented and opened and then 2 ml of 30% H_2O_2 is added and filtered the solutions in 25 ml volumetric flasks and made up with double distilled water. Blanks are prepared by following similar digestion procedure without plant material.

The reaction of Pb (II) metal ion is tested with 2,4–Dihydroxy benzophenone-2-amino thiophenol (BPBT) at different pH values. The samples are prepared in 10 ml of the solution containing constant volume of 2 ml of Pb (II) metal ion, 2 ml of buffer solution at pH= 9.0, 1 ml of 1 x 10^{-3} M BPBT and 2 ml of LiCl solvent. The response solution is after that shaken among 10 ml fractions of methanol for two minutes and after that permissible to stand. Every time the united organic stages of aliquots are in use in 10 ml standard flasks and invented to the mark with methanol solvent. The absorbance is considered in 200 - 800 nm assortments in opposition to reagent blank.

2.4. Recommended procedure

1 ml of BPBT solution, 1 ml Pb (II) metal ion solution and 10 ml of basic buffer solution are taken in to the 25 ml standard flask and diluted up to the mark with double distilled aqueous solution until the clear color solution is formed and then measured the metal complex absorbance against the reagent blank at 347 nm, until then those values are referred to the predetermined calibration curve to calculate the quantity of the Pb (II) metal ion.

3. RESULTS AND DISCUSSION

The Pb (II) metal ion reacts with reagent 2,4–Dihydroxy benzophenone-2-amino thiophenol (BPBT) in acidic medium at pH = 9.0 it produced 1:1 light yellow colored metal ligand complex solution. The metal ligand complex solution has utmost absorbance measured at 347 nm. Hence, most approving response situation for the metal-ligand complex determination is familiar during a numeral of first round studies for instance the effect of reagent concentration, interference of foreign ions, pH, in classify to expand a speedy, choosy and aware non-extractive spectrophotometric resolve of the Pb (II) metal ion at microgram levels.

3.1. Absorption spectra of the reagent BPBT and Pb (II) - BPBT metal complex

The fascination spectrum of Pb (II) and BPBT metal ligand complex and reagent BPBT shows utmost absorbances at 347 nm and 320 nm respectively is given in the Fig.5. The ligand (BPBT) shows low level amount absorbance at the wavelength of utmost absorbance of the metal ligand complex. Hence every spectral measurements of the metal ligand (Pb-BPBT) complex have been carried out at the wavelength 347 nm. The effect of pH on the color intensity of the reaction mixture study shows that the constant and utmost color is obtained in the range of pH 2.0 - 4.0, the metal ligand (M:L) complex has utmost absorbance in the pH = 9.0 basic buffer solution. Thus the analytical studies are carried out at pH = 9.0 basic medium.

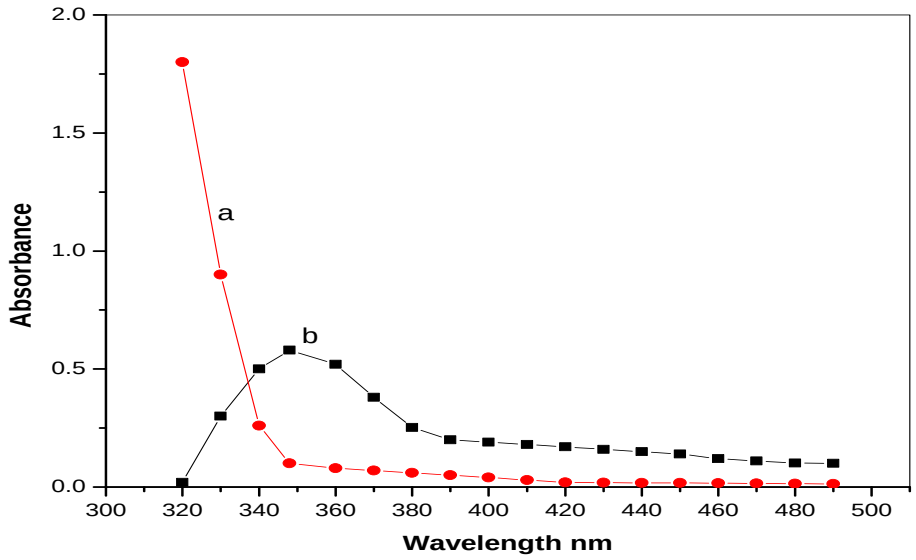

Fig. 5. Absorption spectra of (a). Pb (II) –BPBT complex (λmax=347 nm) in aqueous solution, (b). BPBT Vs Water blank (1x10^{-3} M)

The different molar excess of reagent BPBT solutions are added to the Pb (II) metal attention and the absorbances are considered adopting the regular process. Here it is observed that 10 wrinkle molar surplus of reagent BPBT with admiration to Pb (II) metal ion is essential to acquire utmost absorbance. Thus a 10 wrinkle molar surplus of ligand is used for additional investigational studies. Hence, the absorbance of the 10 wrinkle molar surplus of solutions is considered at different time intervals to establish the time stability of the color metal ligand complex. Hence it is also observed that the color expansion is instantaneous and remained constant for more than 24 hrs. Thus the physicochemical and analytical properties of Pb (II) -BPBT metal ligand complex are summarized in the given Table 1.

Table 1. Physico – Chemical and analytical characteristics of Pb (II) – BPBT complex.

S. No.	Characteristics	Results
1	λ_{max} (nm)	347
2	pH range (optimum)	8.0 – 10
3	Mean absorbance	0.330 ± 0.0008
4	Mole of reagent required per mole of metal ion for full color developed	10 Fold
5	Time stability of the complex (in Hrs)	24
6	Beer's law validity range (µg/ml)	0.27- 2.4
7	Molar absorptivity (L mol^{-1} cm^{-1})	5.59 x 10^4
8	Specific absorptivity (ml g^{-1} cm^{-1})	0.1058
9	Sandell's sensitivity (µg/ml)	0.00178
10	Composition of complex as obtained in Jobs and molar ratio methods (M:L)	1:1
11	Stability constant of the complex	1.23 x 10^5
12	Standard deviation	0.00084
13	Relative standard deviation (RSD)%	1.35135
14	Y-intercept	+0.00342
15	Angular coefficient (m)	0.3305
16	Correlation coefficient (v)	0.9991
17	Detection limit (µg ml^{-1})	0.008
18	Determination limit (µg ml^{-1})	0.024

3.2. Observance of the Pb (II) – BPBT metal composite scheme to Beers law

The fortitude of Pb (II) metal ion at microgram echelon and the absorbance of the metal solution containing diverse quantity of the Pb (II) metal ions are considered at 347 nm. Thus the linear intrigue between the absorbance and the quantity of Pb (II) metal ion is haggard and it given the in a straight line among the equation A_{347} = 0.3305C + 0.00342 is given away in Fig.6. Hence, the Beers law is obeyed in the range of 0.27-2.4 µg/ml, thus the molar absorptivity and sandell's sensitivity of the metal solutions are found to be 5.59 x 10^4 $L.mol^{-1}cm^{-1}$ and 0.0017 µg/cm^2 respectively. Therefore the standard deviation method for the ten determinations of the metal ions is 1.63 µg/ml ± 0.00084 respectively. Hence, the outcomes show that standard deviation of the method is not more than 0.00084 and relative standard deviation is less than 1.35 % of the metal ion. Hence these results are specifying that the method has good precision, besides being accurate for the metal ion.

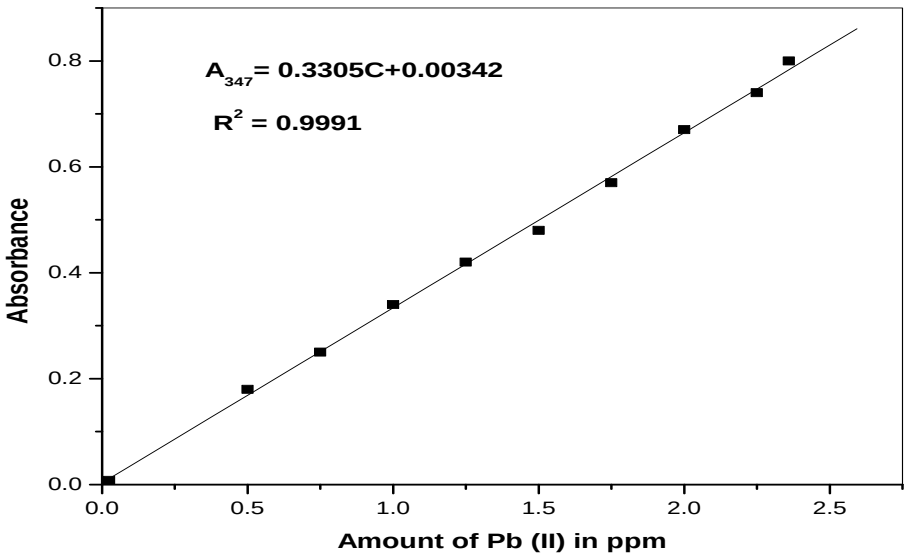

Fig.6. Calibration plot for Pb (II) determination.

3.3. Intervention of Foreign Ions

The upshot of diverse cations and anions which are usually allied with the Pb (II) metal ion in the fortitude of Pb (II) metal ion is studied by measuring the absorbance of Pb (II) metal solution. Therefore the metal ligand composite contains 1.63 µg/ml of Pb (II) metal ion within solution. Hence, the color of the reaction is urbanized in the regular process. A mistake of the

solution is ± 2% in the absorbance reading value is considered acceptable. The tolerance limit (TL) standards in ppm for diverse anions and cations in the BPBT reagent techniques are offered in the given Table 2 respectively. Then the upper quantities of Fe^{3+} do not meddle in the attendance of 70 ppm of fluoride, the bigger quantities of Hg^{2+} do not meddle in the attendance of 600 ppm of iodide solution.

The current technique BPBT ligand is applied for the fortitude of lead (II) when existing lonely and existing in water, soil and medicinal leaf samples. Hence, the current ligand containing aromatic ring it is establish to be prospective and outlay effective for the willpower of Pb (II) metal ion without the required for taking out using the toxic solvents. More the ligands are incredibly effortless to manufacture by using the profitably obtainable predecessors. Furthermore the current spectrophotometric technique is easy, fast and extremely perceptive for non-extractive spectrophotometric fortitude of Pb (II) metal ion in the aqueous medium.

Table 2: Effect of foreign ions.

Ion Added	Tolerance limit µg/ml	Ion Added	Tolerance limit µg/ml
Tartar ate	592	W(v)	368
Iodate	508	Mn (II)	2.2
Urea	288	Pb (II)	8.2
Citrate	384	Cr (VI)	1.1
Bicarbonate	244	TI (III)	0.41
Thiocyanate	232	Cd (II)	0.22
Sulphate	384	Hg(II)	0.40
Oxalate	352	Ni (II)	0.23
Thiourea	304	Fe (II)	0.22
Nitrate	248	Au (III)	0.40
Acetate	236	Pt (IV)	0.39
Phosphate	39	Pd(II)	0.22
Bromide	32	Ag (I)	0.22
Chloride	14	V (V)	0.10
Fluoride	7.8	Cu (II)	0.12

3.4. Composition and stability constant of the complex

The Job's continuous variation and molar-ration methods are applied to find out the stoichiometric composition of the metal ligand complex. Hence it is found that the metal ligand complex forms 1:1 as given away in (Fig.7).

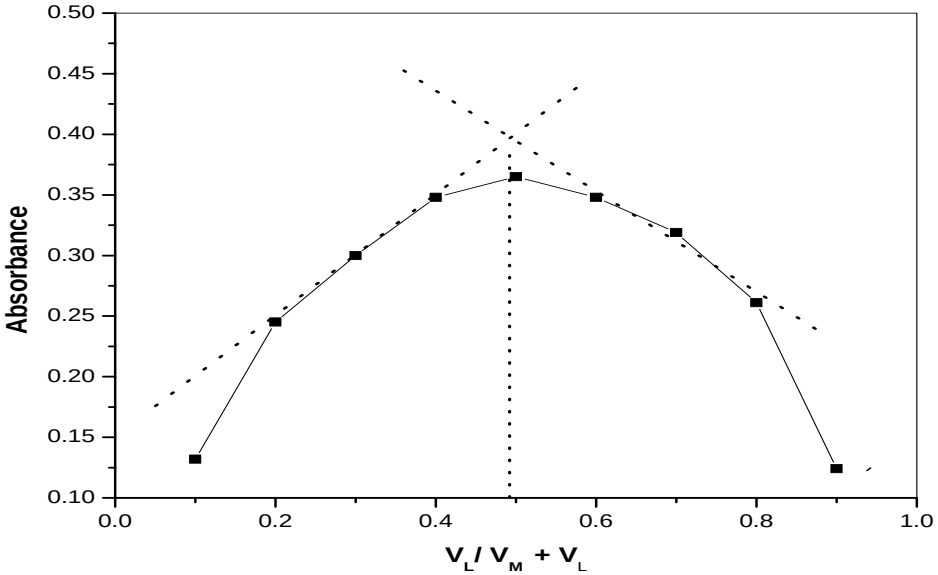

Fig.7. Job's method of continuous variation method Pb (II) - BPBT. Pb (II) and BPBT 1 x 10^{-3} M: solvent-Methanol; (pH = 9.0).

3.5. Application

The proposed Non-extractive spectrophotometric method is applied for the determination of Pb (II) metal ion in water, soil and medicinal leave samples. An identified aliquot of the sample solutions are taken into a 25 ml separating funnel and the lead (II) metal contents are determined as described in the general procedure. Then the sample results are checked with similar determinations by the direct ICP-OES technique. Hence, the results obtained in the analyses of soil, water and medicinal leaf samples are shown in the given Table 3, 4 and 5.

Table - 3. Determination of trace amount of Pb (II) in water samples

Sample Name	Pb(II) found µg/ml					
	ICP-OES	S.D	R.S.D (%)	Proposed Method[a]	S.D	R.S.D (%)
Ground water[b]	0.918	0.0001	0.0174	0.912	0.0001	0.0195
Ground water[c]	0.836	0.0009	0.0108	0.826	0.0002	0.0132
Industrial waste water[d]	1.344	0.0001	0.0081	1.334	0.0001	0.0089
Ground water[e]	0.34	0.0011	0.2988	0.319	0.00017	0.0434
Ground water (upper)[f]	0.132	0.0012	1.0892	0.123	0.0014	0.8050
Ground water (lower)[g]	0.102	0.0001	0.1036	0.101	0.0017	0.1648

a. Average of the five determination
b. Collected at Pollur (Palamaneru-chittoor), A.P, India.
c. Collected at Ranipet , A.P, India.
d. Collected at Karakambadi, A.P, India.
e. Collected at Mahanandi , A.P, India.
f. Collected at Yaganti (upper), A.P, India.
g. Collected at Yaganti (lower), A.P, India.

Table - 4. Determination of trace amount of Pb (II) in Soil samples

Sample Name	Pb(II) found µg/g					
	ICP-OES	S.D	R.S.D (%)	Proposed Method[a]	S.D	R.S.D (%)
Agriculture soil[b]	2.621	0.0001	0.0047	2.618	0.00012	0.0045
Industrial road side soil[b]	2.638	0.0001	0.0041	2.629	0.00011	0.0041

a. Average of the five determination
b. Collected at Karakambadi, A.P, India.

Table 5: Determination of trace amount of Pb (II) in Medicinal leaf samples.

Sample Name	Pb(II) found µg/g					
	ICP-OES	S.D	R.S.D (%)	Proposed Method[a]	S.D	R.S.D (%)
Azadirachta indica[b]	2.762	0.0001	0.0046	2. 753	0.0001	0.0041
Dathura[b]	6.642	0.0001	0.0016	6.624	0.0008	0.0012
Ocimum sanctum[b]	2.502	0.0002	0.0043	2.509	0.0008	0.0031
Grass[b]	1.532	0.0001	0.0065	1.528	0.0001	0.0084

a. Average of the five determination
b. Collected at Karakambadi, A.P, India.

4. CONCLUSION

The researchers have introduced a new sensitive reagent BPBT for the Non-extractive spectrophotometric determination of trace amounts of Pb (II) metal ion. The proposed spectrophotometric method is simple, highly sensitive and selective for the determination of Pb (II) metal ion in various water, soil and medicinal leaf samples and the results are compared with other spectrophotometric methods. The proposed method is simple, rapid and common with metal ions such as Fe^{3+}, Pb^{2+}, Co^{2+}, Ni^{2+}, Zn^{2+}, Mn^{2+}, Cr^{3+}, Urea, bicarbonate, citrate, sulphide, SO_4^{2-}, and PO_4^{3-} which do not interfere. Hence, it also offers advantages like reliability and reproducibility in addition to its simplicity, instant color development and less interference effect of the solution. Thus the outcomes obtained through UV- Visible spectrophotometer have been compared with those obtained results through the ICP-OES method. Thus the spectrophotometric method has been effectively applied for the determination of lead (II) metal ion in the various environmental soil, water and medicinal leaf samples.

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