

DETERMINATION OF HEAVY METALS IN GROUND WATER BY ICP-OES IN SELECTED COASTAL AREA OF SPSR NELLORE DISTRICT, ANDHRA PRADESH, INDIA

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Abstract: Determination of heavy metals up to trace level concentrations with high accuracy and precision is one of the most important concern of the analytical methodology. Number of techniques like ICP-OES, ICP-MS, AAS, Cyclic Voltammetry and UV-Visible Spectrophotometer is employed for the determination of heavy metals in water. Inductively Coupled Plasma- Optical Emission Spectrometer (ICP-OES) is one of the most widely using technique for determination of multi-elements in various environmental matrices in single aspiration. In the present study an attempt has been made to know the concentration of eight heavy metals in ground water of coastal area of SPSR Nellore District, Andhra Pradesh. For this study 35 villages are selected in coastal area of SPSR Nellore district and ground water samples are collected in the selected villages in which the public are using for drinking purpose and subjected to analysis for eight heavy metals like Arsenic (As), Nickel (Ni), Chromium (Cr), Lead (Pb), Cobalt (Co), Selenium (Se), Mercury (Hg) and Cadmium (Cd) by using ICP-OES technique. The concentration levels of these eight heavy metals in the study area are summarized, discussed and compared with drinking water quality standards given by the Indian Standards (IS : 10500) and World Health Organization (WHO), 4th edition in 2011.

Keywords: Ground Water– Heavy Metals – Coastal area of SPSR Nellore – ICP-OES – WHO/IS

I. INTRODUCTION

Ground water is one of the major sources of drinking water in the study area hence it was important to assess the ground water quality with respect to heavy metal contamination. The value of groundwater lies not only in its wide spread occurrence and availability but also in its consistent good quality, which makes it an ideal supply of drinking water. There has been tremendous increase in the demand of potable water due to the rapid increase in the population and industries [1]. Contamination of the groundwater by domestic, industrial effluents and agricultural activity is a serious problem facing by the developing countries. The industrial waste water, sewage sludge and solid waste materials are currently being discharged into the environment indiscriminately. These materials enter subsurface aquifers, resulting in the pollution of irrigation and drinking water [2]. The toxic metals in these effluents are concentrated in the biota, depending on the accumulation factors of the individual metals, thus constituting a potential source of direct intake to contaminants in groundwater and surface water [3-5].

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Heavy metals enter the environment by natural and anthropogenic means. Such sources include: natural weathering of the earth's crust, mining, soil erosion, industrial discharge, urban runoff, sewage effluents and pest or disease control agents applied to plants, air pollution fallout [6]. The pollution of the aquatic environment with heavy metals has become a worldwide problem during recent years, because they are indestructible and most of them have toxic effects on organisms [7]. Among environmental pollutants, metals are of particular concern due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems [8].

Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and biota [9], which generally exist in low levels in water and attain considerable concentration in sediments and biota [10]. Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to be toxic to living organisms [11]. The overexploitation of ground water resources and discharge of untreated effluents induces degradation of ground water quality. Heavy metals enter in ground water from variety of sources, it can either be natural or anthropogenic [12-14]. It is estimated that approximately one third of the world's population use groundwater for drinking [15].

Because of the importance of the heavy metal ions on human metabolism, trace heavy metal analysis is an important part of public health studies [16-20]. Some transition metals at trace levels in our metabolism are important for good health. Heavy metals normally occurring in nature are not harmful to our environment, because they are only present in very small amounts. However, if the levels of these metals are higher than the levels of healthy life, the roles of these metals change to a negative dimension. The main sources of the heavy metal ions directly are food and water and, indirectly, industrial activities and traffic [21-23].

In most of the villages of SPSR Nellore district the public is using ground water for drinking and house hold purpose. There might be chances to get contamination of ground water with different elements and ions at higher concentration levels. In this present study an attempt has been made to evaluate the concentration levels of eight heavy metals in ground water in coastal surrounding villages of SPSR Nellore district, Andhra Pradesh using Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES).

A number of sophisticated instruments like ICP-OES, ICP-MS, AAS, UV-VIS spectrometer, Cyclic Voltammetry, etc. are using for the determination of heavy metals in water. Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES) is based on emission technique. By using ICP-OES technique we can determine minimum 10 ppb levels.

II. MATERIALS AND METHODS

SAMPLE COLLECTION:

The ground water samples are collected by following standard sample collection protocol and guidelines given in Indian Standards methods IS: 3025 (Part-1) and American Public Health Association (APHA) 22nd edition. Special precautions were taken during the collection of samples. Before collecting the samples, the sample containers are soaked overnight in 2% nitric acid and washed with double distilled water and dried in clean metal free area. At each sampling location, water samples were collected in two pre-cleaned containers for duplicate measurement. The bottles were rinsed three times with the ground water sample of the particular location and collected the final sample to avoid the contamination and 0.5 ml of Supra pure grade nitric acid is added to acidify the samples and also to prevent the loss of metals. All the collected ground water samples are preserved at 4°C by using thermo-coal box with ice packs. The details of sampling locations have been summarized in **Table -1**.

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DETAILS OF SAMPLING LOCATIONS:

TABLE -1

LOCATION CODE	LOCATION NAME	LOCATION CODE	LOCATION NAME
GW- 1	SULLURUPETA	GW- 19	JUVVALAPALEM
GW- 2	SRIHARIKOTA	GW-20	THUMMALAPENTA
GW- 3	MEEZURU	GW-21	RAMAYAPATNAM
GW- 4	KATTUVAPALLE	GW-22	AMUDALA PADU
GW- 5	KUMMARIPALLEM	GW-23	NELATURU CHERUVU
GW- 6	ELLORE	GW-24	PYNAPURAM
GW- 7	KOGILI	GW-25	KRISHNAPATNAM
GW- 8	JALAPEDDIPALEM	GW-26	NIDIGUNTAPALEM
GW- 9	MALLAM	GW- 27	MOLLURU
GW-10	VAKADU	GW-28	KAPPALATHERUVU
GW-11	SIDDAVARAM	GW-29	BRAHMADEVAM
GW-12	VENKANNAPALLEM	GW-30	MUTTUKURU
GW-13	GOVINDAPALLI	GW-31	EPURE
GW-14	MOMIDI	GW-32	VARAKAVIPUDI
GW-15	PUDIPARTHI	GW-33	PEDDAMAMBATTU
GW-16	INDUPURU	GW-34	KONDURU
GW-17	ALLURU	GW-35	GOPALAREDDIPALEM
GW-18	KOTHAPALEM	---	---

III. ANALYTICAL METHODOLOGY

Eight heavy metals were analyzed by direct aspiration of ground water samples into Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES) (Varian) system and quantified against by Certified Reference Material (Multi elements-Merck). Five different linear concentration standards were prepared, ranging from 1.0 µg/L to 500 µg/L and aspirated into ICP-OES system before conducting sample analysis, and linear curve was prepared. All metals having good linear graph with correlation coefficient > 0.999 were observed in the preparation of standard curves. After the completion of standard curve preparation, one standard check and one QC check are analyzed.

IV. SPIKE RECOVERY

One Spiked sample is analyzed for every 10 sample study and recovery of spiked concentration has been studied. The spike recoveries are observed minimum of 85% for all metals. Hence the method is rugged to carry-out the ground water sample analysis for determination of metals by ICP-MS.

V. RESULTS AND DISCUSSION

ICP-OES is based on emission technique. By using ICP-OES technique we can determine minimum 10 ppb levels. The quantity of eight heavy metals (Arsenic, Nickel, Chromium, Lead, Cobalt, Selenium, Mercury and Cadmium) observed in

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the 35 villages of coastal area of SPSR Nellore district has been summarized in **Table -2** and the results are discussed below.

TABLE -2
ESTIMATION OF HEAVY METALS IN GROUND WATER
BY ICP-OES TECHNIQUE

S.NO	GROUND WATER	NAME OF LOCATION	Cr	Co	Ni	As	Se	Cd	Pb	Hg
	UNIT		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	GW-1	SULLURUPETA	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
2	GW-2	SRIHARIKOTA	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3	GW-3	MEEZURU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.035	<0.01
4	GW-4	KATTUVAPALLE	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.012	<0.01
5	GW-5	KUMMARIPALLEM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
6	GW-6	ELLORE	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.013	<0.01
7	GW-7	KOGILI	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
8	GW-8	JALAPEDDIPALEM	<0.01	0.025	0.021	<0.01	0.01	<0.01	<0.01	<0.01
9	GW-9	MALLAM	<0.01	0.043	0.056	0.01	0.015	<0.01	<0.01	<0.01
10	GW-10	VAKADU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
11	GW-11	SIDDAVARAM	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01
12	GW-12	VENKANNAPALLEM	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01
13	GW-13	GOVINDAPALLI	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
14	GW-14	MOMIDI	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
15	GW-15	PUDIPARTHI	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
16	GW-16	INDUPURU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
17	GW-17	ALLURU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
18	GW-18	KOTHAPALEM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
19	GW-19	JUVVALAPALEM	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
20	GW-20	THUMMALAPENTA	<0.01	<0.01	<0.01	0.075	<0.01	<0.01	<0.01	<0.01
21	GW-21	RAMAYAPATNAM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.012	<0.01
22	GW-22	AMUDALA PADU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
23	GW-23	NELATURU CHERUVU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
24	GW-24	PYNAPURAM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
25	GW-25	KRISHNAPATNAM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
26	GW-26	NIDIGUNTAPALEM	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
27	GW-27	MOLLURU	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
28	GW-28	KAPPALATHERUVU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
29	GW-29	BRAHMADEVAM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
30	GW-30	MUTTUKURU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
31	GW-31	EPURE	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

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32	GW-32	VARAKAVIPUDI	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
33	GW-33	PEDDAMAMBATTU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
34	GW-34	KONDURU	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
35	GW-35	GOPALAREDDIPALEM	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

The concentration levels of 8 heavy metals in coastal area of SPSR Nellore district during the study period 2012 by ICP-OES technique are discussed below.

2.1 CHROMIUM:

During the study period 2012 the Chromium has been analyzed by using ICP-OES technique and has been found <0.01 mg/L in all study locations in overall study area. The maximum acceptable limit for Chromium as per IS: 10500 is 0.05 mg/L and maximum acceptable limit as per World Health Organization is 0.05 mg/L. However the observed concentration levels of Chromium are observed within the permissible limits of IS: 10500 and WHO guidelines in all 35 ground water samples in study period in the year of 2012.

2.2 COBALT:

During the study period 2012, Cobalt concentrations vary from <0.01 mg/L to 0.043 mg/L in the overall study areas. The maximum concentration of Cobalt has been observed at Mallam village. No acceptable limits are given for Cobalt in both IS: 10500 and WHO guidelines.

2.3 NICKEL:

During the study period 2012 the Nickel concentration levels in ground water locations of study area are varied from <0.01 mg/L to 0.056 mg/L in the overall study areas. The maximum concentration of Nickel has been observed at Mallam village. The maximum acceptable limit for Nickel as per IS: 10500 is 0.02 mg/L and maximum acceptable limit as per World Health Organization is 0.07 mg/L. The observed concentration levels of Nickel in the study area are within the permissible limits of IS: 10500 except Mallam village and within the guide line value given in WHO guidelines.

2.4 ARSENIC:

During the study period 2012 the Arsenic concentration levels in ground water locations of study area are varied from <0.01 mg/L to 0.075 mg/L in the overall study areas. The maximum concentration of Arsenic has been observed at Thummalapenta village. The maximum acceptable limit for arsenic as per IS: 10500 and World Health Organization is 0.01 mg/L. As per IS: 10500 the Arsenic permissible limit relaxable upto 0.05 mg/L in absence of alternative drinking source. The observed concentration levels of Arsenic in the study are within the permissible limits of IS: 10500 and WHO guidelines except Thummalapenta village, but the concentration within the permissible limit of IS: 10500.

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2.5 SELENIUM:

During the study period 2012 the Selenium concentrations levels in ground water locations of study area are varied from <0.01 mg/L to 0.02 mg/L in the overall study areas. The maximum concentration of Selenium has been observed at Venkannapalem village. The maximum acceptable limit for Selenium as per IS: 10500 is 0.01 mg/L and provisional guideline value as per World Health Organization is 0.04 mg/L. The observed concentration levels of Selenium in the study area are within the permissible limits of IS: 10500 except Mallam and Venkanapalem villages, however the selenium concentration levels of these two villages are within the provisional guideline value given by WHO standards.

2.6 CADMIUM:

During the study period 2012 the Cadmium has been analyzed by using ICP-OES technique and has been found <0.01 mg/L in all study locations in overall study area.

2.7 LEAD:

During the study period 2012 the Lead concentration levels in ground water locations of study area are varied from <0.01 mg/L to 0.035 mg/L in the overall study areas. The maximum concentration of Lead has been observed at Meezuru village. The maximum acceptable limit for Lead as per IS: 10500 and WHO guidelines is 0.01 mg/L. However the observed concentration levels of Lead in the study area are within the permissible limits specified in the IS: 10500 and WHO guidelines except Meezuru village. The primary source of lead is from service connections and plumbing in buildings. Lead concentrations can also vary according to the period in which the water has been in contact with the lead-containing materials.

2.8 MERCURY:

During the study period 2012 the Mercury has been analyzed by using ICP-OES technique and has been found <0.01 mg/L in all study locations in overall study area. The maximum acceptable limit for Mercury as per IS: 10500 is 0.001 mg/L and WHO guidelines are 0.006 mg/L. However the observed concentration levels of Mercury in the study area are within the permissible limits specified in the IS: 10500 and WHO guidelines.

VI. CONCLUSION

Ground water is one of the major important drinking water sources throughout the world. Especially in most of the village areas the public are using ground water for drinking purpose. Heavy metals are most considerable contaminants in ground water. Excess levels of heavy metals might cause several short term and long term health effects to the human beings. Determination of these heavy metals with high accuracy and precision at trace levels is one of the major challenges in analytical chemistry. ICP-OES is one of the most widely and universally using technique for determination of heavy metals up to trace levels. The present study is focussed on determination of eight heavy metals like Arsenic (As), Nickel (Ni), Chromium (Cr), Lead (Pb), Cobalt (Co), Selenium (Se), Mercury (Hg) and Cadmium (Cd) in coastal surrounding villages of SPSR Nellore district. For this study 35 ground water samples are collected and subjected to analyze for As, Ni, Cr, Pb,

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Co, Se, Hg and Cd by using Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES) technique. The minimum and maximum concentration levels of these eight heavy metals are summarized and discussed in the results and discussion concentrations of these eight heavy metal levels in the study area were compared with drinking water quality standards given by the Indian Standards (IS : 10500) and World Health Organization (WHO), 4th edition in 2011. In the overall study area the concentration levels of Arsenic in Thummalapenta, Nickel in mallam village, selenium in venkannapallem, Lead in meezuru villages are observed higher levels acceptable limits of IS : 10500. However the concentration levels of these eight heavy metals observed within the permissible limits of IS: 10500 and WHO guidelines.

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