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Infrared Spectroscopy Analysis of ground water- A pilot study

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ABSTRACT

The access to safe drinking water is a worldwide problem and is increasing day by day. The problem of safe drinking water is an extreme problem of public health issue. In present work the spectroscopic analysis of ground water collected from rural area of Punjab India i.e. KotlaMugla from Gurdaspur has been presented. Spectra were used to know the bonds of the compounds present in ground water sample and also to study their chemical properties.

Keywords: - Ground water, Spectroscopy, FTIR, Chemical Composition

1. Introduction

Safe water is very much important for public health. Water plays an important role in the world of living organisms. It is an essential part of the healthy living. The Contaminated water can cause various health risks likewise,diarrhoea, dysentery, hepatitis A, typhoid etc. Many research studies have been devoted on the various aspects of water such as the composition, physico-chemical properties, spectroscopic analysis, and contamination of the water etc[1].

Few researches are mentioned in literature where work is done to test the quality of water.Singh Surinder et.al.[2]analyseduranium and its correlation with some physico-chemical properties of drinking water samples from Amritsar, Punjab. For the estimation of Uranium in drinking water,they used fission track technique, which was developed by Fleischer and Lovett. The Uranium concentration was found to lie between 3.19 to 45.59 μL^{-1}. The Anodic stripping Method was used to determine heavy metals like lead, zinc, copper and cadmium. Various physico-chemical properties like pH (using pH meter), TDS (using standard evaporation method), conductance (using conductance meter), total hardness that is calcium and magnesium using standard EDTA method, sodium and potassium using flame photometry, nitrate (spectrophotometrically), chloride using Mohr's method etc. were determined. A positive

correlation between Physico-chemical properties and Uranium was observed but correlation between heavy metals and Uranium was not observed.

Kumar A. etal[3]conducted a study to investigate the presence of Arsenic and other trace metals in groundwater. The study was done in some part of the Indus basin, Punjab, India. If concentration in ground water is higher than 10 µg/L, it can cause various types of health diseases; it also acts as a carcinogen. The region of study was bari doab which includes Amritsar and Tarantaran districts of Punjab, India. A total of 73 groundwater samples were collected from public and private wells. Some of the parameters like pH, electrical conductivity and oxidation reduction potential were determined on-site.various types of cations like potassium, sodium, magnesium, calcium and trace elements like As, Cd, Zn, Mn, Cr, Fe were analyzed in the laboratory. Anion analysis for NO_3^- was done using UV-Visible spectrophotometer. Sulphate concentration was estimated using turbiditymeter and standard titrimetric method was used for determinining the concentration of chloride and bicarbonate. Health risk assessment was also done using US EPA standards, hazardous quotient, chronic daily intake through ingestion, and hazardous index were calculated. Geochemical modeling was also done using Aquachem 4.0 database and saturation indices. In the study it was found that the As and Fe with low ORP was present mostly along the Ravi river. High concentration of sulphate and nitrate was found, Zn and Cu was also found at shallow depth. High concentration of bicarbonate and calcium and magnesium and sodium was also observed. How As enrichment happens is not clear and a detailed study is needed in this regard.

Virk H.S.[4] presented a comprehensive study of contamination of groundwater due to metals like Arsenic, Selenium and Uranium. In this paper it is mentioned that 60% habitations which are Arsenic contaminated are found in Majha belt of Punjab which include Amritsar, Tarantarn, Gurdaspur. It is mentioned that highest number of Arsenic contaminated areas are in Amritsar.Selenium contamination is found in highest number in Jalandhar district of doaba belt. Malwa districts are contaminated by Uranium. Some methods for the removal of these metals are also discussed like use of ferric sulphate or aluminum sulphate or by using lime softening, reverse osmosis can remove uranium to large extent. Mitigation of Arsenic can be done by using AMRIT technology (Arsenic and metal removal by Indian technology. Mitigation of selenium is also mentioned in the paper. It is concluded that Arsenic is predominant in Majha region of Punjab. Heavy metal contamination of groundwater in Punjab is very alarming.

Virk H.S.[5] presented a report on groundwater contamination of Majha belt of Punjab due to heavy metal Arsenic,it is mentioned that 60% habitations which are Arsenic contaminated are found in Majha belt of Punjab which include Amritsar, Tarantarn, Gurdaspur. Arsenic removal can be achieved by AMRIT methodology.

TiwariReetietal[6] under took the study of Quality Assessment of Groundwater Sources of Punjab, India.508 samples from northern, central and southern regions of Punjab were collected. Various Physico-chemical Parameters like pH, TDS, turbidity, colour, Dissolved oxygen, electrical conductivity etc. were determined and Bacteriological contamination was also analyzed. Some of the parameters were analyzed in-situ and for other standard methods in the lab were used. Bacteriological characteristics (Total coliforms (TC) and faecal coliforms (FC)) were analyzed using multiple tube fermentation method. Correlation among various parameters was determinedandsignificant correlation was found among various parameters. Bacteriological analysis is also done.

Sharma T. etal[7] did a comprehensive study of seasonal variation of Uranium in ground water in the Majha region of Punjab India. The districts which lie in this region are Amritsar, pathankot, tarantaran and gurdaspur. For collecting samples the region was divided in 6*6 km^2 and from each grid a sample was collected. various physic-chemical parameters were determined like pH, TDS, EC total hardness, samples were analysed for anions like chlorine, nitrate, fluoride, sulphates etc. this was done to determine a correlation between these parameters and uranium distribution. U in water samples was estimated by LED- fluorimeter. Uranium content in samples collected from Amritsar was higher as compared to samples collected from gurdaspur and pathankotdistricts.but in all the three districts the Uranium content was with in safe limits.

Rani R. etal[8] used different spectroscopic techniques like near infrared spectroscopy, Fourier transform infrared spectroscopy and fluorescence spectroscopy to analyze the ground water from the Phagwara region falling in the district of Kapurthala, Punjab, India. FTIR peaks were observed at 3743.93cm^{-1}, 3217.67cm^{-1}, 1641.43cm^{-1}, 449.43cm^{-1}. Fluorescence data was collected between 190 to 400 nm for excitation and 300 to 800 nm range of emission. Peaks were observed at 446.49nm, 482.98 nm and at 669.54nm. It is concluded that FTIR and fluorescence spectroscopy can be used to identify the bonds in ground water.

Yuanzheng Zhang etal[9]used fluorescence excitation emission matrix (EEM)-parallel factor analysis (PARAFAC) coupled with multivariate statistical methodsto identify groundwater pollution occurring due to livestock farming. Investigation was done to characterize dissolved organic matter (DOM) in grundwater.Three clusters namely Cluster A, B and C(unpolluted, highly polluted, moderately polluted respectively)were analysed. The intensity of tryptophan was found to be high in polluted water and was almost nil in unpolluted water. Nitrate was found in cluster B and C but was very low in A. The fluorescence spectroscopy can be used to identify monitor the groundwater pollution from live- stock farming.

2. Material and Methods

2.1 Sample Collection

In the present work the spectroscopic analysis of the water sample from theMajha Region of the Punjab has been presented. Gurdaspur is one out of the four districts falling in the Majha region of Punjab, India. It has strong historical importance in Punjab. Its total area is 2610 square kilometer. Two main rivers Ravi and Beas pass through this district. The district lies between northlatitude 31^0-36′ and 32^0-34′ and east longitude 74^0-56′ and 75^0-24′ and is at the foot hills of Himalayas.KotlaMugla is a village falls in the tehsil Kalanaur of Gurdaspur and is 1km from Kalanaur. Its elevation above sea level is 245 metres.

Ground water sample was collected from the village Kotlamogla in Gurdaspur from a tube well from the depth of 250 feet. The sample was collected in dried glass bottles. Sample was analyzed by FTIR and NIR spectroscopy

2.2 Chemical Analysis

2.3 Spectroscopic Analysis

Spectral data was collected using NIR and FTIR spectrometer. NIR spectra was collected using NIRDS2500 spectrometer at CSIR-CSIO, Chandigarh and FTIR spectra was obtained using the spectrometer at CIF lab, Lovely Professional University. Data was obtained in absorbance mode.

3. RESULT AND DISCUSSION

The sample details about the region, source of collection, turbidity, TDS, EC, pH and other parameters are shown in table 1.

Table 1 Details of the ground water sample under study

District	Gurdaspur
Region	Rural KotlaMugla
Source of Water	motor
depth in feet	250
TURBIDITY (NTU)	0
TOTAL DISSOLVED SALTS (TDS) (mg/Litre)	296
ELECTRICAL CONDUCTIVITY (µmhos/cm)	458
pH VALUE	6.88
TOTAL HARDNESS ($CaCO_3$)(mg/Litre)	90
CHLORIDE as Cl (mg/Litre)	31

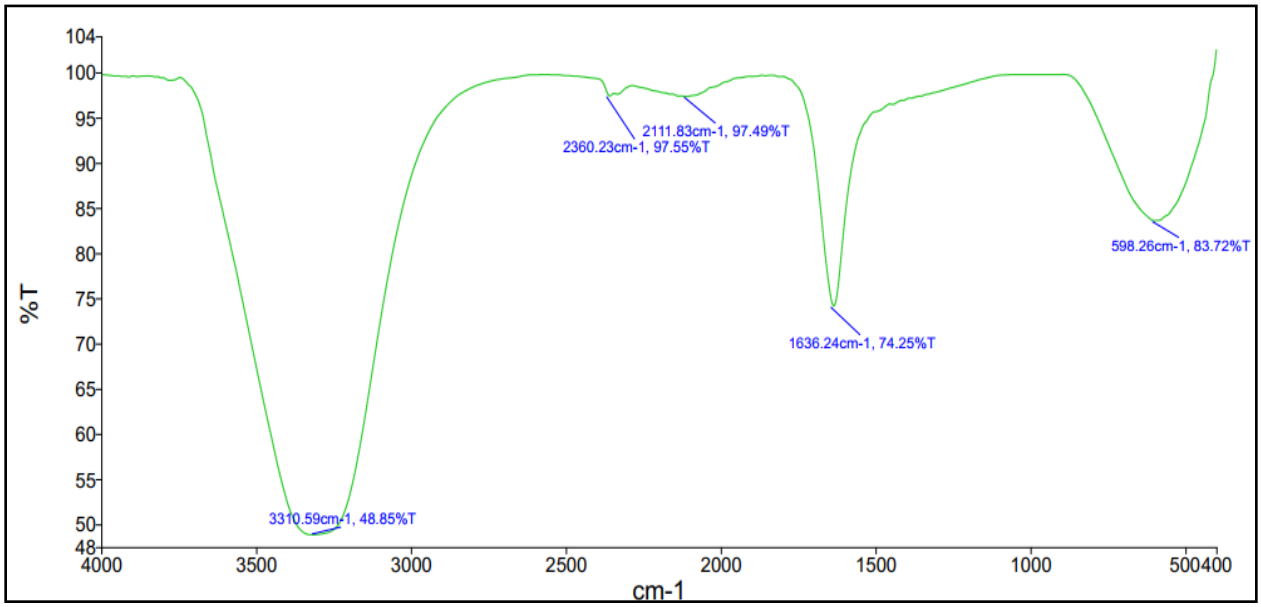

Figure 1 FTIR spectra of the ground water sample

FTIR spectra

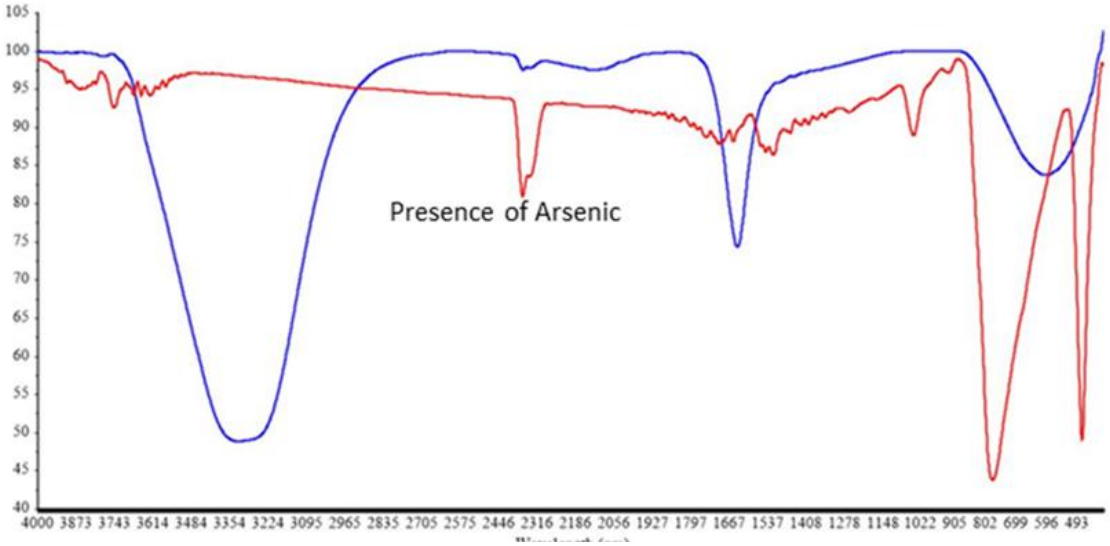

Figure 2 FTIR spectra of pure Arsenic Trioxide (in red) and ground water sample (blue) on wavenumber in cm^{-1} (X axis) and Transmittance in % (Y axis)

The spectrum of the ground water sample and arsenic trioxide were compared and it was observed that transmittance at 2361 cm^{-1} there is a strong transmittance in arsenic trioxide and a small transmittance in the sample. This gives a relation that this arsenic trioxide may be present in the sample.

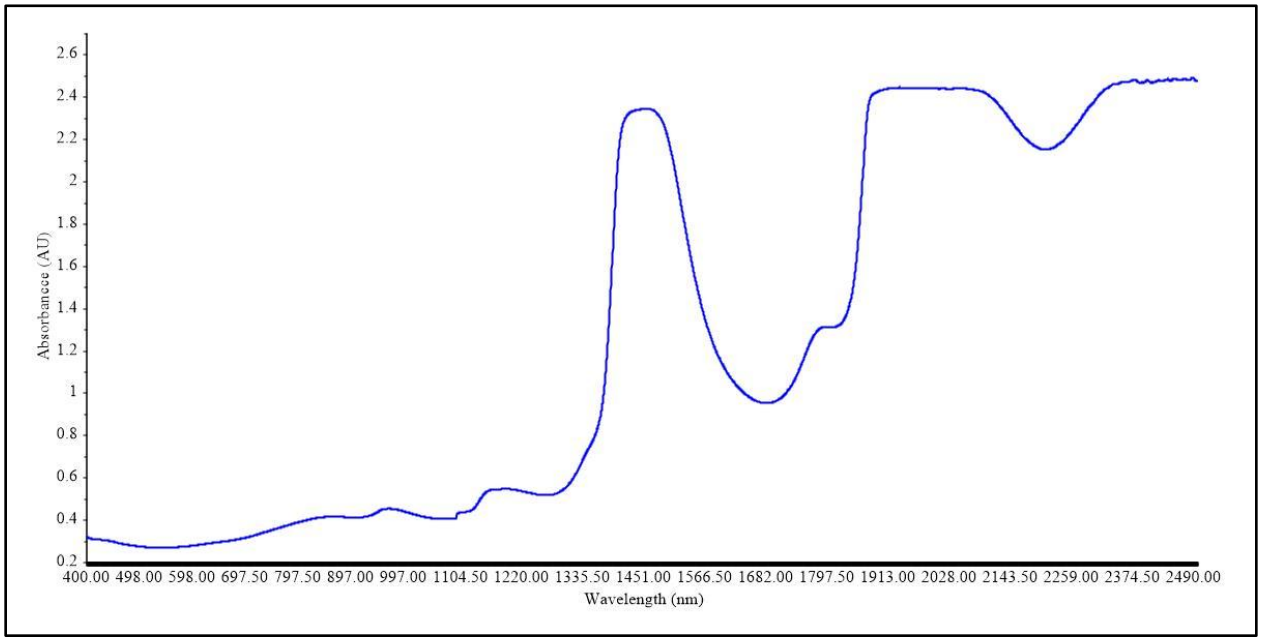

Figure 3 NIR spectra of the ground water sample

NIR Spectra shows the harmonic and combinations bands for the ground water sample. The dip at 2361 cm^{-1} corresponds to 4235.49 nm. This is one of the signature wavelengths of As_2O_3. 1^{st} and 2^{nd} harmonic corresponding to this wavelength are 2162.745 nm and 1441.83 nm respectively. A peak in NIR spectra was observed around 2162 nm, which confirms the presence of the arsenic trioxide in 2^{nd} harmonic vibration.

Conclusion

The pilot study showed that the Sample collected with depth 250 ft had total dissolved salts (TDS) (mg/Litre) – 296, electrical conductivity (µmhos/cm) – 458, pH value - 6.88, total hardness ($CaCO_3$)(mg/Litre) – 90 and chloride contentas Cl (mg/Litre) -31. FTIR spectra of the sample was compared with FTIR of Arsenic. It was observed that at wavenumber around 2361cm^{-1} peak was observed but with different intensity.NIR spectra showed peaks of high intensity for wavelengths higher than 1400 nm and the peak of 2162 shows the presence of the arsenic trioxide in the sample.

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