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Assessment of Pesticides use and Heavy Metals Analysis of Surface and Ground Water Sources by Atomic Absorption Spectroscopy at Nagaur Region, Rajasthan (India).

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Abstract:

Potable water contamination is a major part of the determination of water quality. Potable water qualities in many countries are affected by industrialization and the use of pesticides in agricultural practices. The objective of this study was to detect metal concentration in potable water in the Nagaur district of Rajasthan. The surface and groundwater samples were collected near the agricultural practices. The six sampling locations were ponds and twelve sampling locations were tube wells, and hand pumps of different villages. The samples were analyzed by using atomic absorption spectrometry to determine the concentration of dissolved metals in water.

The Nagaur district has been known for using a heavy amount of pesticides on crops and vegetable farms. This study attempted to assess the extent of the use of pesticides and their implication in the depleting surface and groundwater sources and to examine if there is heavy metal contamination in surface and well-water used for domestic purposes. The method employed to assess the extent of use of pesticides included AAS, field survey, and key informants, whereas water samples from the wells, ponds, and hand- pumps were analyzed in the laboratory to assess lead, copper, chromium, cobalt, arsenic and mercury content in the water.

The groundwater analysis showed that the high concentration of Cobalt at G-3 (Phagali village) at 1.30mg/l, mercury at G-10(Phagali village) at 1.70mg/l, Arsenic at G-3 (Mundwa village) and G-4(Kharnal village) 1.20mg/l, lead at G-6 (Khumari village) and G-11 (Bhadwasi village) 1.2mg/l, Cadmium at G-1 (Tausar village) 1.2mg/l. The high concentration of surface water analysis showed that cobalt at S-2 (Lakholav Talab) at 1.40mg/l, lead at S-1 (Basani Talab) at 1.0mg/l, chromium at S-4(Jada Talab) at 0.50mg/l above the accepted limit. The results obtained were compared with guidelines for drinking water quality such as the Environmental Protection Agency (EPA) and World Health Organization (WHO) guidelines. There is a growing awareness about the adverse effects of pesticides and yet all households interviewed in the study were found to be using pesticides. Nonetheless, a majority of the respondent believes that the use of pesticides has been progressively reduced.

Key Words: Contamination, Water, Pesticides, Atomic Adsorption Spectroscopy, Metal.

[1] Introduction:

The importance of the heavy metal ions on human metabolism, and trace heavy metal analysis is an important part of public health studies. Some transition metals at trace levels in our metabolism are important for good health [1]. 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 a healthy life, the roles of these metals change to a negative dimension in the human body [2]. The main sources of the heavy metal ions directly are food and water and, indirectly, industrial activities and traffic. Drinking water is also an important source of heavy metals for humans. The levels of heavy metal ions in drinking water are generally at mg/l [3].

The flame atomic absorption spectrophotometer (F-AAS) has been widely used for the determination of heavy metal ions in water samples because of its high specificity. However, the direct determination of trace concentrations of these elements by F-AAS is generally difficult because of matrix interference problems and concentrations below the detection limit of F-AAS. These problems can be overcome by using pre-concentration techniques for precise and accurate analysis of heavy metal ions in drinking water it is possible to use neutron activation analysis (NAA), inductively coupled plasma-mass spectrometry (ICP-MS), inductively coupled plasma-atomic emission spectrometry (ICP-OES), x-ray fluorescence spectrometry, and graphite furnace atomic absorption spectrometry (GF-AAS). However, these techniques are expensive and difficult to use [4]. The Separation/Pre-concentration-Flame atomic absorption spectrometry (F-AAS) combination is an important alternative for these techniques due to the cheap cost and easy usage of F-AAS. Organizations like the World Health Organization and the European Committee recommend limits for drinking water that require much greater sensitivity in measurement than is obtainable by flame atomic absorption spectrometry. Pre-concentration-separation techniques like co-precipitation, liquid-liquid extraction, cloud point extraction, and ion exchange are used before flame atomic absorption spectrometric determination of heavy metals in drinking waters [5].

Nagaur district is agricultural land with diverse cultures, physiographic regions, and climates. A majority of the people here are engaged in agriculture. Due to the rapidly growing population, the practice of traditional farming has been gradually changing to modern methods of farming using modern techniques and inputs. To maximize profit, especially from commercial farming, the use of pesticides has become necessary in today's agriculture. Since the demand for food products increases, it is expected that the use of pesticides would increase [6].

Pesticide is a substance used for preventing, controlling, destroying, or mitigating pests. These chemicals are the poison that, in certain circumstances, and does, kills organisms harmful to crops [7]. Pesticides have become a major input in farming for better yield. However, due to the excess use of pesticides, though the crops and vegetables are thriving, it might reduce the quality of water in the area when those pesticides get mixed with the water sources. They could get washed from farms into the river during rainfall or get percolated into the soil contaminating the groundwater. Contamination of groundwater occurs when unwanted substances move through fractures or the soil profile to the saturated zone. The quality of groundwater is affected by the use of various products in agriculture like pesticides, insecticides, and other chemical agents used to kill pests and other soil micro-organisms. Pesticide enters surface and groundwater primarily as runoff from crops and is most prevalent in agricultural areas. Groundwater contamination is higher when there is no crop or when they are young. Pesticides not taken up by plants, absorbed by soils, or broken down by sunlight, soil organisms, or chemical reactions may ultimately reach groundwater sources. Some heavy metals like mercury, lead, cadmium, arsenic, iron, aluminum, and copper are used in pesticides. Traces of these heavy metals could reach the water sources through the same process when washed from the soil. Pesticides continue to break down underground usually much slower than in surface layers of soil. Groundwater contaminated with pesticides away from the original point of application can lead to contaminated well samples years later in a different location [8-9].

The objective of this research was to assess pesticide use and examine the presence of heavy metals in surface and groundwater sources. The study also has attempted to establish linkages, if any, between pesticide uses and changes in water quality due to heavy metals.

[2] Sampling Methods:

Samples were collected from surface and groundwater sources in the Nagaur region of Rajasthan (India). Surface water samples were collected from six different ponds and groundwater samples were collected from tube wells, and hand pumps.

Figure 1. Tube well at Gogalav village

Figure 2. Chenar Talab

Sixteen sampling locations for well water, hand-pumps, and ponds were selected from the Nagaur district as given in table-1 and table -2. From each site, three samples were stored in sterilized bottles to prevent any contamination for laboratory analysis. Preservatives were added and all of them were correctly labeled.

Table -1.Ground water sampling stations (G-1 to G-12 Villages) at Nagaur district of Rajasthan.

S.No.	Sample No.	Village	Source of Sample
1.	G-1	Tausar	Tube well
2.	G-2	Phirod	Hand pump
3.	G-3	Mundwa	Tube well
4.	G-4	Kharnal	Hand pump
5.	G-5	Gogalav	Tube well
6.	G-6	Khumari	Tube well
7.	G-7	Inana	Hand pump
8.	G-8	Rol	Tube well
9.	G-9	Basani	Hand pump
10.	G-10	Phagali	Hand pump
11.	G-11	Bhadwasi	Tube well
12.	G-12	Bhadana	Tube well

Table -2.Surface water sampling stations (S-1 to S-6 ponds) at Nagaur district of Rajasthan.

S.No.	Sample No.	Sample Site	Source
1.	S-1	Basani Talab	Pond
2.	S-2	Lakholav Talab	Pond
3.	S-3	Chenar Talab	Pond
4.	S-4	Jada Talab	Pond
5.	S-5	Pratab sagar	Pond
6.	S-6	Khimsar Talab	Pond

[3] Principle and Methodology:

A Perkin-Elmer Model analyst 200 Atomic Absorption Spectrophotometer equipped with a single element hollow cathode lamp and 10 cm air–acetylene burner was used for the determination of the metals ions. A pH meter, HANNA pH-211 digital glass electrode was used to measure pH values. MSE Mistral 2000 model centrifuge was employed for the centrifugation of solutions. Chemicals used in this study were analyte grade and further purification was not required. Standard stock solutions containing 1000 mg/mL of nitrate salts of Pb(II), Cr(III), Co(II), Ni(II), and sulfate of Cd(II) were prepared in 1 L volumetric flasks and made up to the mark with distilled de-ionized water. A solution of 8-hydroxyquinoline (0.1%, w/v) was prepared by dissolving 0.1 g of the salt in ethanol and then diluting it with ethanol in a 100 mL volumetric flask [10].

3.1 Background absorption:

Background absorption is the non-specific attenuation of radiation at the analyte wavelength caused by matrix components. To compensate for background absorption, correction techniques such as continuous light source (D2-lamp), Zeeman, or Smith-Hieftje should be used. Enhanced matrix removal due to matrix modification may reduce background absorption [10-11].

3.2 Non-spectral interference (Matrix effect):

Non-spectral interference arises when components of the sample matrix alter the vaporization behavior of the particles that contain the analyte. To compensate for this kind of interference, the method of standard addition can be used. Enhanced matrix removal by matrix modification or the use of a L´vov platform may also lead to a reduction of non-spectral interferences.

Atomic absorption spectrophotometer single or double-beam instrument having a grating monochromator, photomultiplier detector, adjustable slits equipment for flameless atomization (graphite furnace), and a suitable recorder or PC. The wavelength range must be 190-800 nm. Hollow cathode lamps for As, Cu, Cr, Ni, Pb, and Zn. Single-element lamps are preferred, but multi-element lamps may be used if no spectral interference can occur. Electrode-less discharge lamps may be used if available [12].

Table -3. All chemicals must be of analytical grade or better:

Distilled de ionized water	
Nitric acid	(HNO_3) 65%
Sodium arsenite	($NaAsO_2$)
Cadmium metal	(Cd)
Potassium chromate	(K_2CrO_4)
Copper sulphate	($CuSO_4$. $5H_2O$)
Nickel sulphate	($NiSO_4.6H_2O$)
Lead nitrate	($Pb (NO_3)_2$)
Zinc metal	(Zn)
Palladium nitrate	($Pd(NO_3)_2$)
Magnesium nitrate	($Mg(NO_3)_2$)
Lanthanum nitrate	($La(NO_3)_2.6 H_2O$)
Ammonium phosphate	($(NH4)_3PO_4$)
Argon (Ar) as purge gas.	

Figure.3 Structure of F-AAS

Figure. 4 Analyses of Heavy metal by AAS

3.3 Standard stock solutions (1000 mg ml-1)

As 1000 mg ml-1:

Transfer 9.733 g $NaAsO_2$ to a 1000 ml volumetric flask. Add distilled de-ionized water to dissolve the salt. Add 5 ml 1:1 HNO_3 and dilute to the mark with distilled de-ionized water. Store the solution in a polyethylene bottle.

Cd 1000 mg ml-1:

Transfer 1.000 g cadmium metal to a beaker. Dissolve the metal in 10 ml 1:1 HNO_3. Transfer the solution to a 1000 ml volumetric flask. Dilute to the mark with distilled de-ionized water. Store the solution in a polyethylene bottle.

Cr 1000 mg ml-1:

Transfer 3.734 g K_2CrO_4 to a 1000 ml volumetric flask. Add distilled de-ionized water to dissolve the salt. Add 5 ml 1:1 HNO_3 and dilute to the mark with distilled de-ionized water. Store the solution in a polyethylene bottle.

Cu 1000 mg ml-1:

Transfer 3.930 g $CuSO_4$* $5H_2O$ to a 1000 ml volumetric flask. Add distilled de-ionized water to dissolve the salt. Add 5 ml 1:1 HNO_3 and dilute to the mark with distilled de-ionized water. Store the solution in a polyethylene bottle.

Ni 1000 mg ml-1:

Transfer 4.477 g $NiSO_4$*$6H_2O$ to a 1000 ml volumetric flask. Add distilled de-ionized water to dissolve the salt. Add 5 ml 1:1 HNO_3 and dilute to the mark with distilled de-ionized water. Store the solution in a polyethylene bottle.

Pb 1000 mg ml-1:

Transfer 1.599 g $Pb(NO_3)_2$ to a 1000 ml volumetric flask. Add distilled de-ionizedde-ionized water to dissolve the salt. Add 5 ml 1:1 HNO_3 and dilute to the mark with distilled de-ionized water. Store the solution in a polyethylene bottle.

Zn 1000 mg ml-1:

Transfer 1.000 g zink metal to a beaker. Dissolve the metal in 10 ml 1:1 HNO_3. Transfer the solution to a 1000 ml volumetric flask and dilute to the mark with distilled de-ionized water. Store the solution in a polyethylene bottle [13].

Commercially available standard solutions may also be used.

3.4 Calibration standards

Calibration standards are prepared by single or multiple dilutions of the stock metal solutions. Prepare a reagent blank and at least 3 calibration standards in the graduated amount in the appropriate range of the linear part of the curve. The calibration standards must contain the same acid concentration as in the samples following processing. For precipitation samples, that would be 1% (v/v) HNO_3 and for suspended particulate matter10% (v/v) HNO_3. The calibration standard should be transferred to polyethylene bottles [14].

Calibration Range:

	As	Cd	Cr	Cu	Pb	Ni	Zn
Calibration range (mg l^{-1})	0-100	0-5	0-40	0-50	0-50	0-40	0-5

3.5 Instrument Procedure of AAS:

The operating instructions will vary between various brands and models of satisfactory instruments, making it virtually impossible to give precise details of a proposed AAS method that is guaranteed to reduce interference effects on all commercial instruments. The instrument manual should be confirmed in regards to operating instructions [15]. A careful interference study and calibration procedure as given in the particular instrument manual must be carried out by the analyst. Some general guidelines are given below.

- Allow the light source(s) a stabilization time of 10-15 minutes before analyzing.
- Set the monochromator to the appropriate wavelength.
- Align the furnace for maximum transmission of radiation.
- Carefully balance the intensity of the hollow cathode lamp and the D2-lamp if such background correction is used.
- Temperature calibration of the furnace should be done.
- Optimize the injection position of the autosampler capillary in such a way that the sample droplet is gently placed in the bottom of the graphite tube. A convenient sample volume for most analyses is 20 ml.
- Make sure that the silica windows in the furnace compartment are clean to ensure maximum transmission of radiation.
- All-new graphite tubes must be thermally conditioned as described by the manufacturer.
- For quantification of absorption signals peak area is recommended.

A temperature program consists most commonly of four steps: Drying, pyrolysis, atomization, and cleaning.

Drying step:

A quick ramp (5 s) to 15oC below the boiling point of the solvent. Then a slow ramp (25 s) to reach a temperature just above the solvent's boiling point. This provides gentle evaporation without sputtering. Hold the furnace at the selected temperature until drying is complete (5- 10 s). The drying time will vary with sample volume and salt content. A purge gas flow of 250-300 ml min-1 is normally used [16].

Pyrolysis step:

A pyrolysis curve should be made to find the appropriate temperature to use in this step without losing any analyte. Consult the instrument manual for the procedure of making a pyrolysis curve. In a pyrolysis step, a typical ramp will vary between 20-50 oC S-1. A too steep ramp may cause sputtering. A purge gas flow of 250-300 ml min-1 is normally used.

Atomization step:

An atomization curve should be made to find the appropriate temperature to use in this step. Consult the instrument manual for the procedure of making an atomization curve. The lowest temperature that still gives the maximum signal should be used to extend the lifetime of the graphite tube. Zero ramp time is used in this step. Gas stop during atomization is recommended [17].

Cleaning step:

A tube cleaning cycle after the analyte measurement should be done to remove any remains of the sample and thereby avoid memory effects. A purge gas flow of 250-300 ml min-1 is normally used [18].

The characteristic mass (sometimes called sensitivity) is defined as the absolute mass of an element that will absorb 1% of the incoming radiation. This equals a signal of 0.0044 absorbance units (AU). The characteristic mass may be used as an indicator of instrument optimization. Values of the characteristic masses are most often given in the instrument documentation. Experimental values for comparison can be determined by measuring the absorbance signal (area) of a known mass of analyte and calculate using the following formula:

mo = Vs * Cs*0.0044 AU / observed peak area

mo: Characteristic mass (ng)

Vs: Standard volume injected (ml)

Cs : Standard concentration (ng ml-1)

Table - 4. Proposed instrument parameters obtained by the AAS method of water samples (ground and surface) near agricultural land, Nagaur, Rajasthan.

Metal	L, nm	slit	Drying temp	Pyrolysis temp	Atomization temp	Chemical modifier	Pyrolysis temp.	Atomization temp.
As	193.7	0.7	120	500	2300	$Pd(NO_3)_2^+$ $Mg(NO_3)_2$	1300	2200
Cd	228.8	0.7	120	350	1800			
Cr	357.9	0.7	120	1350	2660	$Mg(NO_3)_2$	1650	2450
Cu	324.7	0.7	120	900	2600			
Pb	217.0	0.7	120	550	2000	$(NH_4)_3PO_4$	700	1750
Ni	232.0	0.2	120	1200	2600			
Zn	213.9	0.7	120	350	1800	$Mg(NO_3)_2$	700	1750

To achieve better separation between analyte and matrix before atomization, a chemical modifier can be used. The role of the modifier is most often to stabilize the analyte making higher temperatures in the pyrolysis step possible without any loss of the analyte. The concentration level of most modifier mixtures is usually at the ppm-level. The injection volume most often is in the 5-20 µl region. The modifier mixture should be injected and dried before sample injection. For suggestions of chemical modifiers for the various elements.

- Start the analysis with an “empty tube” run. If a significant signal is obtained, a cleaning step (2650oC, 2-3 s) should be run repetitively to remove the remains in the tube. If this is not sufficient, the graphite tube should be replaced.
- The chemical modifier solution (if used) should be checked for contamination in a separate run.
- The blank solution should be analyzed to establish a blank level.
- In addition to the blank standard, at least 3 standards should be selected to cover the linear range. Repeat the analysis until a good agreement between replicates and a linear calibration curve is obtained.
- A quality control standard should be analyzed to verify the calibration.

Samples that are found to have a concentration higher than the highest standard should be diluted into a range and re-analyzed [19].

[4] Result and discussion:

Sample No.	Name of Site	Concentration of Heavy Metal (mg/l)							
		Cr	Co	Ni	As	Se	Cd	Pb	Hg
G-1	Tausar	0.08	0.20	0.30	0.40	0.40	1.2	0.05	1.0
G-2	Phirod	0.10	0.10	0.50	1.0	0.05	1.12	0.02	0.08
G-3	Mundwa	0.10	0.20	4.4	1.2	0.08	0.50	1.10	0.05
G-4	Kharnal	0.02	0.08	1.0	1.2	0.01	0.09	0.01	0.08
G-5	Gogalav	0.10	0.10	0.20	0.01	1.10	0.05	0.12	0.50
G-6	Khumari	0.12	0.11	1.0	0.06	1.20	0.50	1.20	1.20
G-7	Inana	0.10	0.22	0.25	0.05	2.50	0.06	0.16	0.08
G-8	Rol	0.02	0.03	0.06	0.21	1.0	1.0	0.20	0.30
G-9	Basani	0.03	0.02	0.05	1.1	0.70	0.12	0.50	1.0
G-10	Phagali	0.20	1.30	0.01	0.05	1.20	0.05	0.01	1.70
G-11	Bhadwasi	0.31	0.08	1.10	0.01	0.05	1.1	1.20	0.05
G-12	Bhadana	0.22	0.25	0.30	0.06	0.05	0.05	0.50	0.06

Table - 5. Analysis of heavy metals in groundwater sources (G-1 to G-12villages) by AAS.

S.N.	Heavy metal	Result(mg/l)	Mean	S.D.	Error
1.	Cr	0.02-0.31	0.1166	0.0834	±0.0241
2.	Co	0.02-1.30	0.2241	0.3321	±0.0958
3.	Ni	0.01-4.40	0.7641	1.1583	±0.3343
4.	As	0.01-1.20	0.4458	0.4933	±0.1424
5.	Se	0.01-2.50	0.6950	0.7192	±0.2076
6.	Cd	0.05-1.20	0.4866	0.4651	±0.1342
7.	Pb	0.01-1.20	0.4225	0.4592	±0.1325
8.	Hg	0.05-1.70	0.5083	0.5474	±0.1580

Table - 6. Analysis of heavy metals in surface water samples (S-1 to S-6 ponds) by AAS.

Sample No	Name of site	Concentration of Heavy Metals (mg/l)							
		Cr	Co	Ni	As	Se	Cd	Pb	Hg
S-1	Basani Talab	0.02	0.90	1.10	0.05	0.01	0.08	1.0	0.07
S-2	Lakholav Talab	0.40	1.40	0.80	0.90	2.1	1.20	0.9	0.02
S-3	Chenar Talab	0.008	0.08	0.05	0.05	1.2	1.1	0.05	0.07
S-4	Jada Talab	0.50	0.50	0.02	0.03	0.20	0.10	0.03	0.10
S-5	Pratap sagar	0.05	0.20	1.00	0.40	0.10	0.20	0.01	0.05
S-6	Khimsar Talab	0.20	1.0	0.50	0.08	1.2	0.20	0.01	0.50

Table - 7. Comparative study of Ground water parameters by AAS (G-1 to G-12 Villages).

S.N.	Heavy metal	Result(mg/l)	Mean	S.D.	Error
1.	Cr	0.008-0.40	0.1963	0.1922	±0.0784
2.	Co	0.08-1.40	0.6800	0.4640	±0.1894
3.	Ni	0.02-1.00	0.5616	0.4082	±0.1666
4.	As	0.03-0.90	0.2516	0.3168	±0.1293
5.	Se	0.01-1.20	0.4866	0.5087	±0.2077
6.	Cd	0.08-1.20	0.4800	0.4767	±0.1946
7.	Pb	0.01-1	0.3333	0.4372	±0.1784
8.	Hg	0.02-0.50	0.1350	0.1650	±0.0673

Table - 8. Comparative study of surface water parameters by AAS (S-1 to S-6 ponds).

4.1 Graphical presentation of surface and groundwater parameters.

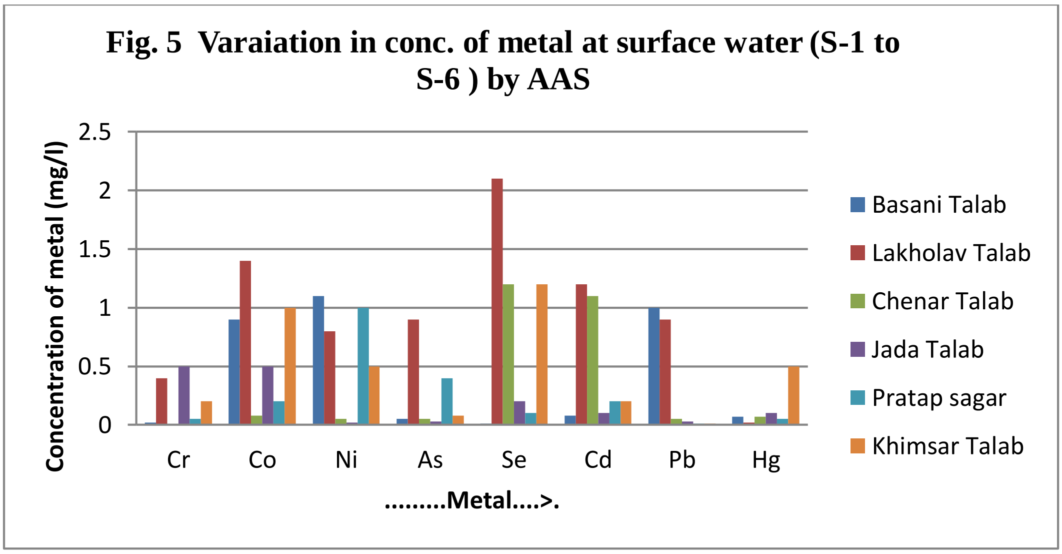
Fig. 5 Varaiation in conc. of metal at surface water (S-1 to S-6) by AAS

Fig.5 shows that a high concentration of selenium, cobalt, and cadmium was obtained at the Lakholav pond, which is above the acceptable limit of WHO standards. High concentration of lead, arsenic, and nickel at Pratap Sagar and Lakholav ponds which are also above the acceptable limit of WHO standards.

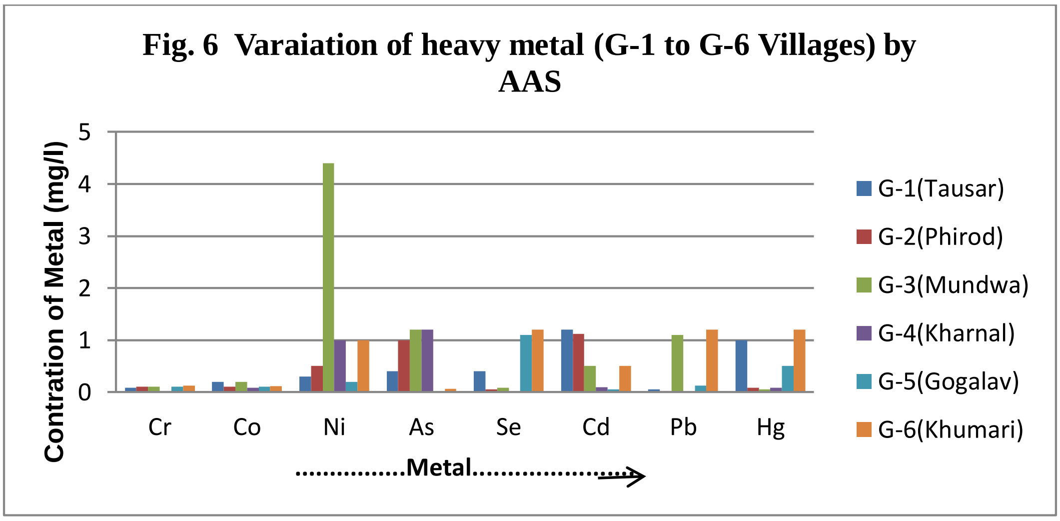
Fig. 6 Varaiation of heavy metal (G-1 to G-6 Villages) by AAS

Fig.6 shows that comparative study of Groundwater samples, the highest concentration of nickel obtained at G-3 (Mundwa) village is above the WHO standards, and this water isn't used for drinking purposes.

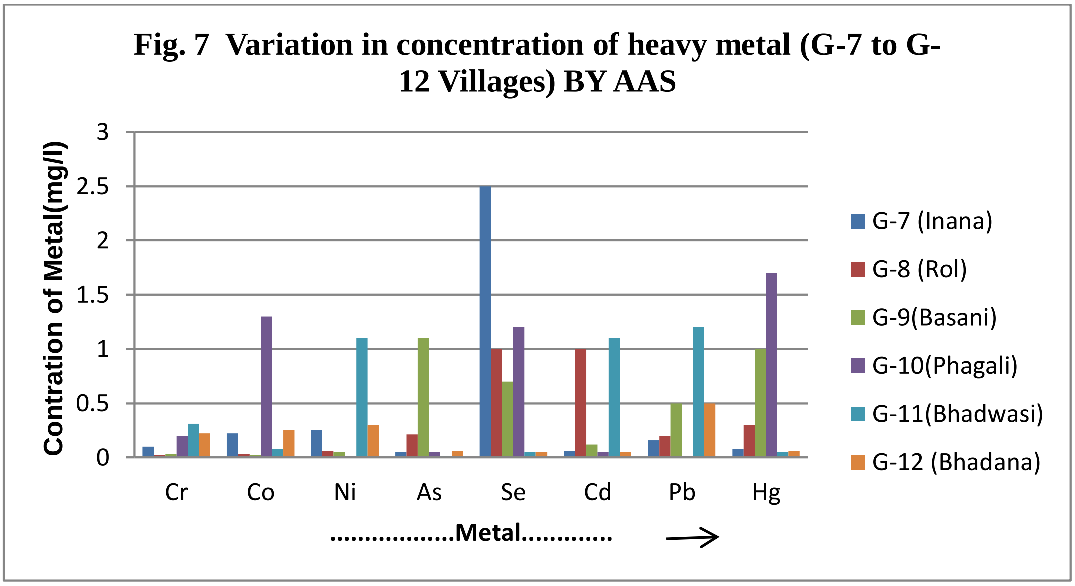

Fig.7 shows the comparative study of G-7 to G-12 samples of heavy metal parameters in which the high concentration of cobalt, mercury obtained at G-10 (Phagali) village and high concentration of selenium obtained at G-7 (Inana) village which are above the WHO standards, this water is not used for drinking purposes.

4.2 Comparatively discussion of different water parameters:

The levels of chromium, nickel, selenium, cadmium, lead, mercury, and cobalt in drinking water samples from the Nagaur district were determined by atomic absorption spectrometry. The results are given in Table -5 for groundwater samples and in Table- 6 for surface water samples. Chromium concentrations in natural water, including drinking water, are usually very small. Chromium in water supplies is generally found in the hexavalent form. The chromium range was 0.008-0.40 mg/l. The lowest level of chromium was in Chenar Talab. The highest level of chromium was found in sample G-11 from Bhadwasi village. The acceptable concentration of total chromium in drinking water was 50 µg/l [20].

International regulations on water quality are lowering the maximum permissible levels of potentially toxic metals in humans [21]. Nickel concentration of drinking water samples (G-1 to G-12) range was 0.01 to 4.4mg/l. The mean value of nickel in surface water samples is 0.5616 and in groundwater samples was 0.7641. Nickel values of four samples were higher than the mean value. The highest nickel level was found in the drinking water sample from Mundwa (4.4 mg/ l) and the lowest in the samples from Phagali (0.01 mg/l) (Table 5). Cobalt in the samples was in the range of 0.02-1.40 mg/l. The lowest and highest values were in Basani village, Lakholav pond, respectively, but even in most of the samples, Cobalt was considerably below the limit of 1.0 mg/l permitted by WHO in drinking waters [22].

The mean level of cobalt concentration was 6.01 µg/l. Consequently, no contamination due to cobalt exists in the investigated drinking water samples from the Nagaur district of Rajasthan (India). It is reported that arsenic concentration in drinking water samples ranges from 0.01 to 1.20mg/l. The highest arsenic level was found at Mundwa, and Kharnal villages, 1.20mg/l, and the lowest in Bhadwasi village, 0.01mg/l. The mean value of arsenic in groundwater samples was 0.4455 and in surface water samples was 0.2516. WHO has recommended a guideline value of 0.1 mg/l of arsenic in drinking water [23]. None of the drinking water samples analyzed for manganese exceeded the limit permitted by WHO, which agrees with results obtained by other authors in other countries. The main industrial uses of zinc are galvanization and preparation of alloys [24]. The main source of arsenic in natural waters including drinking waters may be pesticides that are used in agricultural practices.

Selenium in drinking water is present as Se^{+2}, Se^{+3} in the suspended form [25]. While the lowest selenium level was in the Basani Talab water sample at 0.01mg/l, the highest selenium concentration was in Inana village water samples at 2.50mg/l. WHO has proposed a guideline value of 0.3 mg/l for drinking water. The average values of selenium in all samples are below the maximum allowable concentration. The highest level of cadmium was in the sample from Tausar village, Lakholav pond respectively (1.20mg/l), and the lowest level of Cd was Bhadana and Gogalav village (0.05mg/l). However, the mean value of cd in surface water samples was 0.4800 and in groundwater samples was 0.4651 which was below 10 µg/l, the limit permitted by WHO. The highest value of lead in drinking water samples from Basani Talab, Khumari village, Bhadwasi village were 1.0mg/l, 1.20mg/l, and 1.20mg/l respectively. The mean value of lead in surface water samples was 0.3333 and the mean value of groundwater samples was 0.4225, it is present only in trace concentrations in natural waters. The highest level of mercury was in a sample from Jada Talab (0.1mg/l), Phagali (1.70mg/l), and Khumari (1.20mg/l) and the lowest level of mercury was Pratap Sagar (0.05mg/l), Mundwa village (0.05mg/l). Drinking water samples were collected from the water supplies at different locations in the Nagaur district of Rajasthan, India.

[5] Conclusion:

Arsenic, lead, and mercury is widely distributed in the environment because their natural and anthropogenic sources are pesticides in the Nagaur region of Rajasthan.

In surface and groundwater, arsenic is found dissolved in inorganic and organic forms monomethyl arsenic acid (MMA) and dimethyl arsenic acid (DMA). Inorganic arsenic is known to have high levels of toxicity, the allowable limits of arsenic in natural mineral water and water for human consumption were reduced to 10 mg/l total arsenic. Obtained levels in analyzed waters were above the acceptable limits (0.90mg/l to 0.01mg/l). The high value of arsenic obtained at G-1 (Tausar), G-4(Kharnal) villages which are above the acceptable limit, and the minimum value of arsenic obtained at G-11(Bhadwasi), G-10 (Phagali) villages which is the inacceptable limit (WHO standards).

The highest value of lead was obtained at G-4(Kharnal) village, S-2 (Lakholav) pond by ICP- Mass Spectroscopy, and G-11 and G-6 villages by Atomic Absorption Spectroscopy. The maximum permissible limit for lead in drinking water is 0.01 mg/l. The values obtained in the analyzed waters are above the acceptable limit. A high level of lead in potable water causes lead poisoning in the human body. When this happens, a person may feel memory loss, loss of appetite, headache, and nervous system damage [26]. These are agricultural practices in villages of Nagaur district. The most important anthropogenic source of lead in the environment is the combustion of gasoline and pesticides [27].

The highest value of mercury was obtained at G-6 (Khumari) village, G-10(Phagali) village, and S-6 (Khivsar) pond which are above the acceptable limit of WHO standards. A high concentration of mercury causes harmful effects on human beings.

For surface water samples characterized by a lower degree of pollution, the concentration of rare metals is close to or even below the limit of quantification, the concentrations were within the range 0.01-0.9 mg/l.

The highest concentrations of cobalt in samples of G-10 (Phagali), G-5 (Gogalav) villages (up to 1.2 mg/l) that its level exceeds the maximum permissible value for drinking water which is 1.0 mg/l.

Cobalt could be present in water in ionic form or complex organic minerals. Cobalt, in particular, plays a dual role in the metabolism of photosynthetic organisms. It is both a micronutrient and a toxicant depending on the dose [28-29].

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