

Flame Photometric: Water Quality Analysis By using two parameters Sodium Adsorption Ratio (SAR) and Sodium percentage (Na%)

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Abstract: Ground water is one of the main sources of drinking and irrigation in most of the areas in Haryana. The present study aims at determining the quality of groundwater. Sodium adsorption ratio, sodium percentage, pH and conductance were used for water quality analysis. The quality of ground water was analyzed for the purpose of its suitability in irrigation. For this study, nine samples of groundwater were collected from deeper Bore holes, tube wells, hand pumps and Wells in the local areas of Bhiwani district (Haryana). The quality analysis in the study was based on Standard Adsorption Ratio (SAR) and Sodium percentage (Na%) by using flame photometric technique and volumetric method. The estimation of sodium and potassium was carried out by flame photometer and calcium and magnesium by complexometric titration by EDTA. pH and EC were analyzed by using Digital pH-Meter and Digital conductometer. This study concluded that the water samples collected were not suitable for the irrigation purposes.

Keywords: SAR, Flame photometer, Sodium, Potassium, Sodium percentage

1. INTRODUCTION

In the mid of 15th century, Georgius Agricola in his paper *De Re Metallica* described the "color of fumes" from different types of ores [1]. This may be the oldest record present in which the flame was used as a source for excitation and for recognition of metal based on its color. So, it was the beginning of the flame photometry as an analytical tool. After 150 years, in 1704, Newton published his disquisition on color and nature of light. Then, this disquisition was re-evaluated various times and the fourth edition was issued in 1704 [2]. After Newton, Melville also studied the nature of light and colors, although he did not concretely show a connection between the color to sample composition [3]. Flame Photometry is the oldest technique that was introduced in the mid of 19th century by Kirchhoff and Bunsen. This technique was based upon the principle that metallic element shows a characteristic radiation when it is subjected to the suitable excitation device that is flame. Then, the instrument was designed for the quantitative analysis of metals in given sample. Janssen in 1870 introduced a sample of the platinum wire and used Bunsen burner as an excitation source and the concentration of Na was determined by the visual comparison with the known standard concentration [4,14]. After that in 1873, P Champion, Pellet, and Grenier TM designed an instrument for sodium analysis. This was the first instrument used for quantitative analysis of metals by using flame as an excitation source [5,15]. Although, there were some limitations of using this instrument, the first one was how to control the amount of sample introduced into the flame and second was the flame size. To overcome these limitations, in 1877 Gouy introduced a pneumatic atomizer to spray limited amount of sample into the flame and these works helped to increase the accuracy and precision [6,7,14]. In 1920's Lundegardh introduced a nebulizer that helped to present a sample in aerosol form in the acetylene or air flame [8,14]. In late 1940, there was a wide range of instruments available for the quantitative analysis of alkali and Alkaline metals. With accuracy for determination of intensity, colored filter was used for the selection of wavelength of atom and a visual display photocell/galvanometer was used to note down the intensity of emissions. Usually the flame photometer is designed to determine the intensity of characteristic spectral emissions of atom that excited by the flame sources having temperature range of 1000-3000°C. This low range of temperature is helpful to atomize the alkali and Alkaline metals that spray into the aerosols form. Estimation of water quality was carried out by standard method given in Table 1 [15-16]. pH representing the hydrogen ion concentration in water is a scale to examine the quality of water quickly. Normally the pH range 6.5-8.5 lies in the category appropriate for irrigation. The pH beyond this range may be suitable for irrigation but has the strength to disproportion of nutrients or cause of poisonous ions in soil. The low pH value in water sample facilitates the corrosion [18]. Electric conductivity (EC) is usually described in terms of salinity. Water salinity is directly related to the crop productivity as it affects the crop plant by decreasing the capacity to compete with ions in the sample solution for quality of water. The salinity and water quality both are contradictory to each other as high EC decreases the quality of ions in water and the less amount of water is available for crop because water used for growing by the plant is only pure water. The quality of ions decreases when EC for water increases. Electric conductivity examines salinity from all dissolved ions in water like anions Cl^- , NO_3^- etc. and cations like Mg^{2+} , Ca^{2+} , Na^+ , K^+ etc. The preferred units used for EC are micro-Siemen per centimeter and mhos per centimeter [19].

Table 1 gives the details about elements, method used, instrumentation and references used for water quality analysis

Elements	Analytical Method	Instrumentation	Reference
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Na+	Flame Photometric	Manti- Model MT- 126	Stanford and English (1949)
K+	Flame Photometric	Manti- Model MT- 126	Stanford and English (1949)
Ca ²⁺ and Mg ²⁺	Complexometric Titration	—	Jackson (1973)
pH	--	S-109 Digital PH-meter	Jackson (1973)
Conductance	--	S-941 Digital Conductometer	Jackson (1973)

2. EXPERIMENTAL DETAIL AND DATA ANALYSIS

2.1 Characteristic Wavelength Showed by the Alkali and Alkaline Metals

Generally, Alkali and Alkaline Metals get excited by absorbing a radiation when given heat and energy from different sources. The absorbed radiation emits characteristic wavelength in the visible region. For example, sodium gives an emission of yellow color in flame.

Table 2 gives details of emissions of alkali and alkaline metals in terms of characteristic wavelength and the colors produced by it.

Table 3 gives details about the temperature produced by the different oxidants used as sources of flames.

Elements	Colors of flame	Characteristics wavelength (nm)
(Na) Sodium	Yellow	589
(K) Potassium	Violet	766
(Li) Lithium	Red (carmine)	670
(Ca) Calcium	Orange	622
(Ba) Barium	Lime green	554

2.2 Study Area

In the present disquisition,

Name of Oxidant	Temperature (°C)
Natural gas Air	1700
Hydrogen Air	2000
Hydrogen and Oxygen	2650
Acetylene Air	2300
Acetylene Oxygen	3200
Propane Air	1800
Acetylene Nitrous oxide	2700
Cyanogen Oxygen	4800

the ground water samples were collected from the local areas of Bhiwani district for physico-chemical parameters i.e. sodium percentage (Na%), sodium adsorption ratio (SAR), pH and Electric Conductivity (EC).

Natural water contains sodium, potassium, calcium and magnesium. Sodium is one of the most abundant elements and it is most important part of our body fluids, so this study gives us some useful knowledge about the quality of water used for drinking and irrigation purposes and as per the WHO guidelines, the amount of sodium and potassium in drinking water is limited up to 200mg per liter and 3000mg respectively. As per International Sodium Adsorption Ratio (SAR) standard [10].

$$SAR = \frac{Na^+}{[(Ca^{2+}+Mg^{2+})/2]^{1/2}} \dots\dots\dots eq. (1)$$

As per Indian standard, the suitable SAR for irrigation is always less than 10. And if it is in between 10-18 then irrigation may be permissible and if it is in between 18-26 then the water is doubtful for irrigation and if it is greater than 26 then the water is unsuitable for irrigation. So, by the help of flame photometer we are trying to analyze the quality of water by analyzing the quantities of Na and K in water. For irrigation purpose, percentage of sodium (Na%) was calculated as per standard [11,13].

$$Sodium\ percentage = \frac{(Na^+ + K^+) \times 100}{(Na^+ + K^+ + Ca^{2+} + Mg^{2+})} \dots\dots\dots eq. (2)$$

2.3 Material and Methodology

2.3.1 Experiment 1

As per Indian Standard Institute, Standard solution was prepared. So, we took 2.532 gm sodium chloride and 1.915g of potassium chloride and dried these solids up to 120°C and 400°C temperatures respectively and then cooled it at room temperature in desiccator over silica gel and then transferred the dried sodium chloride into the 1000ml volumetric flask by the help of funnel and added 100ml water to dissolve it and simultaneously added 10ml HCl (hydrochloric acid). After dissolution, added more water to fill the flask up to mark and prepared solution was of 1000ppm concentration. Then we prepared 100, 80, 60, 40, 20 ppm solutions from stock standard Solution by dilution and aspirated the double distilled water to adjust the photocell/galvanometer reading on 00 by using zero control nobe. Then we aspirated the higher concentration stock solution to adjust the reading on 100. For more accuracy, the instrument needs to be warm up for 20 minutes during this period the distilled water should be aspirated. Emission readings were taken for all the standard Solutions. After each reading distilled water should be aspirated as per Standard

Operating Procedure (SOP) given in Equiptronics manual. The standard operating procedure was followed for analyzing sodium and potassium in water samples by selecting specific filter [9].

2.3.2 Experiment 2

To determine the concentration of calcium and magnesium, volumetric or complexometric method was used. First 100ml water sample was boiled and reduced the volume by half then titrated it against 0.01M EDTA after adding ammonia buffer and eriochrome black-T (indicator) and titrated sample against EDTA till color changed from wine red to blue (end-point). The same was repeated for each of the nine samples and calcium and magnesium concentration were determined in water samples.

$$\text{Concentration of calcium and magnesium} = \frac{\text{Volume of EDTA (ml)} \times 1000}{\text{Volume of sample taken (ml)}} \quad \dots\dots \text{Eq (3)}$$

Electrical conductivity (EC) and pH were measured by electric conductometer and pH meter respectively by using standard procedures. EC was examined by using double distilled water as calibrating reagent. After calibration, EC was determined for water samples. For each water sample the conductometer should be calibrated first. And pH was studied by using SYSTONIC Digital S-109 PH-meter. For calibration buffer solution of 4 and 7 pH was used. After calibration electrode was put into the water sample and pH of the water was noted. Before each water sample the instrument should be calibrated by calibrate reagent.

3. RESULT AND DISCUSSION

Bouwer and Idelovitch stated in 1987 that Sodium has negative impact on the crop as it causes leaf burning in avocado, almond and stone fruits. In 2012 the US Food and Drug Administration suggested that intake of sodium is not more than 2400mg/ day. The Sodium hazard for irrigation purpose can be analyzed by SAR, as it is an important parameter for evaluating the suitability of groundwater for irrigation purpose because it is measured by sodium, calcium and magnesium contents. [12] Sodium Adsorption Ratio (SAR) samples showed variation from 13.21-274.72 with an average value of 84.64 (Table 4). The value of SAR clarifies that 22.22% of groundwater samples having SAR value in between 10-18, which showed that these samples having good quality of water for irrigation and on the other hand 77.78% of water samples having SAR value greater than 26, it shows that water quality for irrigation purpose was unsuitable. And the second parameter Sodium Percentage varies from 59.25-124.80 and average value was 89.69. So, only 11.11% samples were found in the category of permissible for irrigation while 88.89% water samples were not allowed for irrigation. The pH range allowed for irrigation and drinking purpose is 6.5-8.5 (BIS: 10500:201) but the collected samples having pH range from 8.47 to 9.23 which were beyond the allowed values. Where the electric conductivity lies in range of 0.40 to 3.45 mhos/ cm and the permissible value of EC for irrigation is <1500 microsiemen /cm. So, all the samples were unsuitable for irrigation. Though physico-chemical parameter pH and electric conductivity (EC) showed that all the water samples were unsafe for crop and hence there were requirements of alternates like filtration.

Water Sample	Na+ (mg/l)	K+ (mg/l)	Ca ²⁺ and Mg ²⁺ (mg/l)	pH	Conductance (mhos/ cm)	Na%	SAR
Halwash	120	120	165	8.59	0.40	59.25	13.21
Bajina	80	124	45	8.47	0.42	80.49	16.84
Karimodh	530	560	75	9.08	1.58	93.56	86.60
Jhumpa	750	684	15	9.41	2.01	124.80	274.72
Budheri	490	564	71	9.10	1.81	93.68	82.35
Shigani	400	480	90	8.89	1.48	90.72	59.70
Mitthi	680	915	355	9.09	3.45	81.79	51.05
Pahari	450	544	135	8.99	1.57	88.04	54.81
Bahal	750	664	75	9.23	2.10	94.96	122.54

Table 4 gives details of the measurable atomic flame emissions of the Na+, K+ in terms of the emission wavelength, volumetrically determined Ca²⁺ and Mg²⁺, pH, Conductivity and calculation of Na% and SAR (two parameter).

Fig1. Graph to represent the SAR and Na%

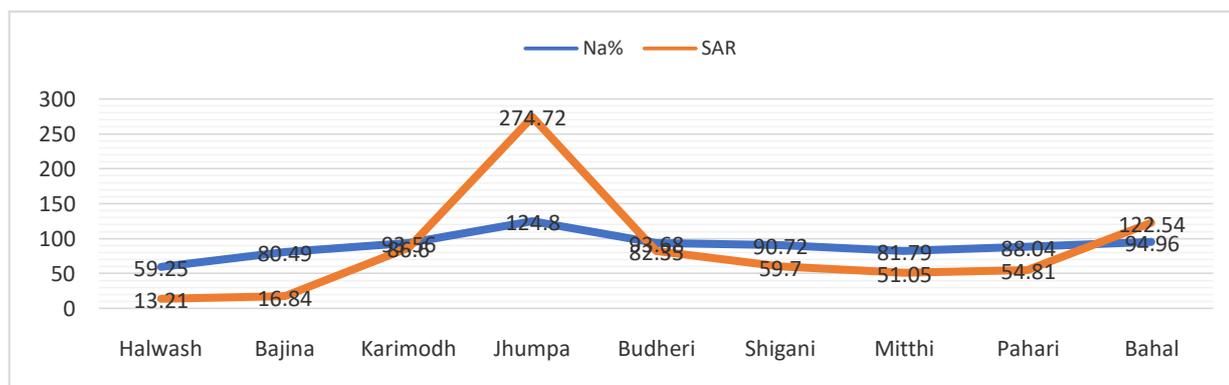


Table 5. Irrigation water parameter classification

Properties	Reference	Standard Value [17,20,21,22]	Classification	No. of Samples	Percentage of Samples
SAR	USSL	<10	Excellent	0	00
		10-18	Good	2	22.2
		18-26	Doubtful	0	00
		>26	Unsuitable	7	77.78
Na%	James et al., 1982	<20	Excellent	0	00.00
		20-40	Good	0	00.00
		40-60	Permissible	1	11.11
		60-80	Doubtful	0	00.00
		>80	Unsuitable	8	88.89
pH	as per BIS: 10500:201	<6.5	Not Permissible	0	00
		6.5-8.5	Permissible	0	00
		>8.5	Not Permissible	9	100
Conductivity (micro Siemen/cm)	NDWQS	<1500	Permissible	0	00
		1500-3000	Not Permissible	0	00
		>3000	Hazardous	9	100

4. CONCLUSION

The quality assessment was made by using four parameters i.e. sodium adsorption ratio (SAR), Sodium percentage (Na%), pH and EC. The sodium concentration in irrigation water may decrease soil hydraulic conductivity of soil structure and damage the soil structure. The extent of sodium adsorbed by the soil depends on the amount of sodium to Ca²⁺(calcium) + Mg²⁺ (magnesium) ratio that is stated as Sodium Adsorption Ratio. SAR parameter can be determined by using the equation 1. The water samples collected from nine ground water sources of local areas of Bhiwani district indicate that the water from most of the ground water sources cannot be used for irrigation purpose. For irrigation purpose Sodium Adsorption Ratio works for measurement of suitability of water. High concentration of sodium can cause damage for crops, so results showed that the 22.22% samples were good for irrigation and 77.78% sample were found to be unsafe for irrigation purpose. And based on sodium percentage the 11.11% samples were permissible for irrigation purpose but 88.89% of samples were unsuitable for irrigation. Though, two parameters pH and EC showed that these nine water samples were not useful for the irrigation purpose. So, it is a matter of consideration that the local people should use some alternates as water filter to improve the quality of water for irrigation.

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