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A Case Study of Physico-Chemical Analysis of Underground Drinking Water of Narwana Block, District Jind, Haryana, India.

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***Abstract*— *According to Indian philosophy nature was created by the God with five panch maha tatva; Agni, Jal, Vayu, Prithvi, Aakash. Jal/Water is one of the most important components of life. Water is a universal solvent, most precious, wonderful and abundant. Water is an essential natural resource on the earth for maintaining life and the environment. All living beings, plants as well as animals need fresh water to maintain life. Over and exhaustive exploitation of natural resources as well as water create severe threats on the ecosystem of the earth. Water has been severely polluted by urbanization and industrialisation. So, it is essential to analyse water quality parameters; pH, electrical conductance (EC), total dissolved solid (TDS), total hardness (TH), total alkalinity (TA), Ca, Mg, K, Na, Cl, F, nitrate, phosphate, sulphate and heavy metal etc. The present study was conducted to analyse the various parameters of underground water in the rural area of Narwana block. All parameters of water compared with the desirable and prescribed limit of World Health organisation (WHO) Bureau of Indian Standard Indian (BIS) and Indian Council of Medical Research (ICMR) standard of drinking water parameters. It has been found from the result that the quality of water in different areas of Narwana is variable, medium to low quality and can be used for domestic use only after suitable treatments. To improve the quality of water various suitable suggestions have been given.*

***Keywords*— TDS, TH, electrical conductance, natural resources, underground drinking water, quality parameters.**

I. INTRODUCTION

The life that originated in water is also sustained by water and hence water is the mother of all the living world. All living beings contain 70% to 95% water in their bodies. Approximately 70% of the human body is made up of water. A large amount of water is also contained by plant tissues. Water is one of the most precious commodities, it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. It acts as a driving force for every civilization and fulfills all live relativity needs, including food, drinking, sanitation, health, energy and shelter. Fresh and clean drinking water is essential to humans and other living beings. So, water is one of the most important nutrients, yet it has no calorific values, but its contribution in structural composition of cells and organelles and is an essential component of diet (Baloch et al., 2000). All the ancient civilizations developed all along near the water bodies in India as well as in the world. Water needs for all metabolism in the body and maintains heat regulation by perspiration. The decrease in water quality creates water scarcity and limits its use and availability for humans and ecosystems and thereby impact on optimum management of water resources. (Rao and Mamta, 2004). Different people have different meanings of pure water. Home owners are primarily concerned with the domestic water problem related to colour, odour, taste and safety to family health. Chemists and engineers want to prevent scale deposition and pipe erosion. Farmers are interested in irrigational (physically, chemically and osmotically) pure water. Water fulfills these terms and conditions and is known as "portable" that means it is used in any desirable amount without concern for adverse effects on health. (AWWA,1990). Approximately 66% of the earth's surface is covered by water, though water is scarce as almost saline in nature. Generally, a small fraction of about 2.5% of fresh water is present on the earth in the form of glaciers, lakes, rivers, ponds and underground water etc which is used for domestic and other purposes. Approximately 13% of this production is groundwater. That is an important source of drinking water for many people worldwide (Bindu and Shelve Mohan, 2009). The groundwater has been used for drinking over a long time and its purity has made it a well-known source of portable water all over the world. Underground water is used for drinking and other purposes in Haryana. More than 50% of the total population of this region meets their daily requirements. Borewell is also used along with the well in many parts of Haryana as a source of portable water (Chauhan and Paliwal, 2009). Groundwater is the major source of water in our country, about 85% of the population depends on it (Giri and Singh et al., 2014).

II. REVIEW OF LITERATURE

Heavy metals are primarily toxic pollutants that hardly affect the beneficial use of water for domestic and industrial application (Ernst,1991). The high level of nitrate in groundwater has been related with excessive use of nitrogenous fertilizer in agriculture and higher amounts of organic waste generated by the human population (Kataria, 2004). Tata Vati and Chandel (2008) have studied the groundwater quality of Jaipur city Rajasthan. An extensive study of modelling of Buckingham canal water quality is available in nature (Abbasi et al., 2002). Contamination in surface and groundwater can range from natural substances leaching from the soil. Water quality deterioration may occur due to sources of faecal pollution including grazing cattle, natural animal pollution, septic tank, failed civil system, recreational users and some other activities etc. (Crabill et al.,1999). Pollution of groundwater resources due to the geological condition has become a matter of serious concern (Rao and Mamta, 2004). Most of the critical quality related problems of groundwater in India are cited as geogenic, largely due to massive inorganic pollutants like Fluoride and Arsenic. Arsenic problems exist in 3136 habitations and fluoride is endemic in 36988 habitations (DdWS, 2004). Over 1 billion people in the world lack a safe water supply to create environmental health risk in early childhood, leading to the permanent growth faltering, lowered immunity and increasing mortality. Poor water sanitation, purification and inadequate water resource management are responsible for half of the causative factor behind childhood and maternal underweight and hence child growth (World Bank, 2008). Approximately 3.01% (1.7 million) of deaths and 3.7% of disability adjusted life years (54.2 million) worldwide are attributable to unsafe water use, poor sanitation and hygiene (WHO, 2005). A review of the literature shows that the study of physico-chemical analysis of underground drinking water is essential. The objective of studying is to investigate and analyse the quality of underground drinking water of Narwana block, district Jind, Haryana, India.

III. STUDY AREAS AND SAMPLING

For sampling, a number of 22 sample sites were chosen in different villages from where 22 samples were collected in post monsoon in October and November months of 2020. The samples were collected in treated and labelled plastic bottles (1.5L) and immediately preserved and analysed following the standard protocol given in the APHA (APHA-1992). Each bottle was washed with 2% nitric acid and then ringed three times with distilled water as well as with site water samples also. Sampling places were referred to as stations (N-1 to N-22). Different sample sites are given in Table 1.

IV. MATERIAL AND METHODS

A number of 22 samples were collected from different sites of villages such as temples, school, water works, bus stand, canals and other places from handpump, tubewell and natural water resources etc. These samples were analysed with various physical chemical parameters and some metals. A portable water analyser kit WTW (WTW multi 340 SET) was used for finding 3 Water quality parameters on the sites and these were pH, water temperature (WT), and electrical conductance (EC). In analysis all Chemicals used are of Standard A.R. grade, and double distil water used for the preparation of solution. The parameters were found by using the standard method recommended in the manual of APHA/AWWA/WEF (APHA-1992). Atomic absorption spectroscope (model 3100) Perkin Elemer USA used for finding heavy metals. Potential of hydronium ion (pH), total dissolved solid TDS measured using pH, TDS and conductivity meter (bridge) respectively. Total hardness (TH), Calcium, Magnesium, total alkalinity (TA) and Chloride estimated by titrimetrically, while Sulphate, Phosphate, Nitrate and Iron were analysed with the help of spectrophotometer. Sodium and Potassium analyse with flame photometer. In the present study minimum, maximum, average and standard deviation have been calculated for each pair of water quality parameters by using an Excel spreadsheet for experimental data. The standard formulas used in calculation post statistical parameters are the (BIS 2012). Details of this method are sunrise in Table 2.

Tabel 1: Sampling Site, Source Code and Depth of water samples

Sr. No.	Sample site	Source	Code	Depth(feet)	Temp. (°C)
1	Ambarsar	Submersible	N-1	293	25.9
2	Barta	Submersible	N-2	68	28.5
3	Belarkha	Handpump	N-3	35	26.3
4	Bhana Brahman	Submersible	N-4	115	27.8
5	Chak Ujhana	Tubewell	N-5	65	28.7
6	Data Singhwala	Submersible	N-6	110	27.4
7	Dhobi Tek Singh	Submersible	N-7	185	27.8
8	Dhandoli	Submersible	N-8	168	23.6
9	Dhanori	Submersible	N-9	120	26.5
10	Garhi	Submersible	N-10	118	25.8
11	Gurusar	Handpump	N-11	65	28.8
12	HansDehar	Submersible	N-12	160	29.2
13	Kharal	Handpump	N-13	85	27.9
14	Koyal	Submersible	N-14	600	29.2
15	Loan	Handpump	N-15	60	27.5
16	Napewala	Manmade well	N-16	70	21.4
17	Nariangarh	Submersible	N-17	78	25.3
18	Padarth Khera	Submersible	N-18	120	26.7
19	Pipal Tha	Submersible	N-19	218	25
20	Rasidan	Submersible	N-20	156	27
21	Rewar	Submersible	N-21	150	25
22	Ujhana	Manmade well	N-22	72	24

Table 2. Analytical methods, BIS, ICMR, & WHO Parameters for drinking water

			Prescribed by				
			BIS (IS 10500-91)		ICMR		WHO
Sr. No.	Parameter	Method employed	Desirable limit	Maximum permissible limit	Desirable limit	Maximum permissible limit	WHO
1	pH	Digital pH meter	6.5-8.5	No relaxation	7.0-8.5	6.5-9.2	6.5-8.5
2	TDS (mg/L)	DIgital TDS meter	500	2000	500	1500-3000	1000
3	TH (mg/L)	Titrimetric (EDTA)	300	600	300	600	500
4	Ca^{+2}(mg/L)	Titrimetric (EDTA)	75	200	75	200	200
5	Mg^{+2}(mg/L)	Titrimetric (EDTA)	30	100	50	–	50
6	Cl^{-} (mg/L)	Titrimetric ($AgNo_3$)	250	1000	200	1000	200
7	Turbidity (mg/L)	Nephelometry	1	5	1	5	5
8	SO_4^{-2} (mg/L)	Spectrometric Method	200	400	200	400	400
9	NO^{3-} (mg/L)	Spectrometric Method	45	100	20	100	10
10	Po_4^{-3}(mg/L)	Spectrometric Method	–	–	–	–	–
11	Na/K (mg/L)	Flame photometer	–	–	–	–	–
12	Fe^{+3}(mg/L)	Spectrometric Method	0.3	1	0.1	1	1
13	F^{-}(mg/L)	APHA-Method	1	1.5	1	1.5	1.5
14	As (mg/L)	APHA-Method	0	0.05	0	0.05	0.05

Experimental Data

V. RESULTS & DISCUSSION

The respective values of all quality parameters in the water samples are listed in Table 3. All results are compared with the standard permissible range recommended by the Bureau of Indian Standard (BIS), Indian Council of Medical Research (ICMR) and World Health Organisation (WHO) depicted in Table 2.

Table 3: Water quality parameters of Narwana Block of District Jind, Haryana

Sample Code	PH	EC (ds/m)	TDS (mg/l)	TH (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	TA (mg/l)	Cl^- (mg/l)	F (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	SO_4^{2-} (mg/l)	PO_4^{3-} (mg/l)	NO^{3-} (mg/l)
N-1	7.82	1.315	863	328	72	35	297	136	0.9	102	7	172	0.6	6
N-2	8.57	0.724	482	197	43	22	162	72	0.8	85	6	67	0.2	18
N-3	8.98	0.494	384	178	38	20	154	67	0.6	72	8	118	1.2	6
N-4	8.02	1.213	742	359	79	39	219	78	0.5	64	4.8	124	0.6	52
N-5	8.15	0.655	526	213	37	29	244	49	4.7	42	9	16	0.4	6
N-6	8.85	0.982	567	258	57	28	213	193	0.7	98	6.2	22	1.7	59
N-7	7.52	0.613	364	162	39	16	156	117	1.5	79	3.7	112	1.2	9
N-8	8.24	0.895	547	261	62	27	217	143	0.9	77	17	53	0.5	58
N-9	7.61	1.865	953	446	107	43	261	136	0.7	99	13	154	0.7	42
N-10	7.69	1.527	842	389	74	50	285	154	1.2	94	12	89	0.4	27
N-11	7.82	1.125	683	370	85	38	232	98	1.4	64	2.8	189	0.5	21
N-12	7.56	0.637	384	216	51	22	177	74	0.5	48	3.4	113	2.8	29
N-13	8.34	1.017	642	302	67	33	186	104	2.7	57	9	102	0.8	16
N-14	8.15	1.498	912	427	94	47	307	133	1.9	84	14	196	0.4	61
N-15	7.52	1.711	1079	596	116	74	341	267	3.4	101	17	152	0.9	43
N-16	8.42	0.868	523	306	64	35	211	98	1.4	76	12	104	1.3	32
N-17	7.86	1.743	1087	627	132	72	497	202	0.2	186	4	375	0.2	24
N-18	7.62	1.265	817	437	88	52	367	156	0.6	129	8	186	1.7	20
N-19	7.74	1.121	689	349	67	44	274	189	1.3	153	12	108	1.4	52
N-20	8.42	0.884	532	276	59	31	271	105	0.4	69	15	102	0.7	34
N-21	7.5	1.287	809	440	88	53	286	212	1.5	172	7	179	1.6	66
N-22	7.45	1.219	753	434	82	56	224	83	0.7	63	8	148	1.2	26

5.1. pH

As we know, pH is used to find hydronium ions concentration, alkalinity and acidity in water samples. On long exposure to high pH above the permissible level affects the mucus membrane of the cells. The pH value of all groundwater samples is found within the range of 7.5 to 8.98. The pH values of all samples are within the permissible range except sample number N-2, N-3 and N-6 have 8.57,8.98 and 8.85 respectively higher than the prescribed range (6.50 to 8.50) of WHO (BIS 2012).

5.2. Electrical Conductance (EC)

The electrical conductance is the measure of capacity of a substance to conduct the electric current when dissolved ions in solution behave as conductors. In water mostly salts present in the ionic form and conduct electric current. Sodium (Na+) Calcium (Ca2+), Potassium (K+) and Magnesium (Mg^{2+}) are the major positive charged ions, which contribute to the electrical conductance. Chloride (Cl'), Fluoride(F'), Nitrate (NO3'), Sulphate (SO4"), Phosphate (PO4"') carbonate (CO3"), bicarbonate (HCO3') are major negative ions collectively those have small contribution to the electrical conductance, but they are biologically very important. EC is a useful parameter or water quality for indicating the salinity hazards. So electrical conductance is a good indicator to find the groundwater quality.

In the present study area electrical conductance is between 0.494 ds/m to 1.895 ds/m. Salinity is measured to find the amount of salt in water. Because dissolved ions increase the salinity as well as conductivity, both are correlated to each other. Salinity influences the organism that lives in the water body and the growth of plants that will grow either in the water body or on the land fed by the groundwater (BIS 2012 Rani et al., 2013).

5.3. Total Dissolved Solid (TDS)

In this study case groundwater samples were found to show the variation of TDS content range between 364 to 1087mg/L. For domestic use the maximum permissible limit of total dissolved solid is 1000 milligram per litre (recommended by the WHO). The maximum value of TDS is recorded at the station N-15 & N-16 have value 1079 and 1087 respectively, except these all samples are in the permissible limit. An elevated level of TDS, by itself, does not indicate that water is a health risk. High concentration of dissolved solids makes the water corrosive, salty, and brackish, resulting in the scale formation (BIS 2012).

5.4. Total Hardness (TH)

In the present case study, total hardness was analysed to show that the water samples were found in the range of 162 to 596 mg/L. Total hardness is the sum of concentration of alkaline earth metal cations such as Calcium and Magnesium. However, The WHO guideline permissible limit is 300 to 600 mg /litre. All samples have range in the permissible limit except the sample N-17 as value 627 mg/L. Drinking of salty water in excess causes hypertension and increases the risk of stroke, left ventricle hypertrophy, osteoporosis, renal stone and asthma. The concentration of Calcium ions in water samples is in the range of 37 to 132 mg per litre. WHO permissible limit minimum to maximum in the range of calcium (75 to 200 ppm) & magnesium up to 50 ppm. All samples are within the permissible limit of calcium and magnesium except N-15 has magnesium content 72 ppm. It has been found that Calcium and magnesium are essential minerals for all living organisms.

5.5. Total Alkalinity (TA)

In the present study case total alkalinity of water samples are in the range of 162 to 497 mg/litre. According to The WHO recommendation total alkalinity prescribed range is 200 mg per litre. Five samples N-2, N-3, N-7, N-12 and N-13 are in the prescribed range and the rest of the sample have a slightly higher value than the prescribed range except N-17 has value 497 mg/litre. Normal value of alkalinity in water is mainly due to bicarbonate and very high value of alkalinity water due to bicarbonate, chloride Sodium and sulphate content in the reported sample.

5.6. Chloride /Fluoride

The concentration of chloride is in the range of 49 to 267mg/litre. WHO permissible maximum concentration of chloride 200 mg per litre. The samples N-15 and N-17 have values 267 and 202 mg/L respectively, slightly above the prescribed values, rest of all water samples are in the permissible level. The high value of chloride content is considered to be risky for human use and causes unpleasant taste of water (Sharma et al., 2004). Fluoride content is in the range 0.2 to 4.7 mg per litre. The permissible range is 0.5 to 1.5mg/L. The sample N-5, N -13 & N-15 have values 4.7, 2.7 & 3.4 mg/L respectively, slightly higher than the prescribed range and rest of all samples are within the range. Some of the cases were recorded in the sampling area of villages which have high values of Fluoride content, causing dental and skeleton fluorosis.

5.7. Nitrate

The content of nitrate is found in the range of 48 to186 mg/litre. The values of nitrate content are commonly reported as either nitrate or nitrate- nitrogen (NO3' -N). The maximum contaminated level (MCL)in drinking water as nitrate is 45 mg per litre, (MCL) NO3' - N is 10 mg per litre. The MCL is the highest level of nitrate and nitrate- nitrogen that is allowable in the drinking water supply as proclaimed by the USA, Environmental Protection Agency (EPA). High content of nitrate in water can cause methemoglobinemia, or blue baby syndrome, a condition found generally, in infants less than 6 months. Because the stomach acid of an infant is not as strong as the older children and adults, this increase in bacteria that can readily convert nitrate to nitrite. The very high value of nitrate in groundwater samples (N-4, N- 6, N- 8 and N-14 and N-21) is due to high value Potassium Nitrate.

5.8. Iron (Fe^{3+})

The iron content of the analyse sample is found within the guidelines of NDWQS and WHO. Iron content is in the normal range of 0.0 to 0.5 mg per litre. Iron is one of the most abundant elements on earth ranking 4th by weight. All types of water including ground water have a high value of iron is concerned as health hazards but still it is considered as an exceeding quantity of iron for domestic as well as industrial uses.

5.9. Sodium/ Potassium ions

The content of Sodium in drinking water samples is in the range of 48 to 186 milligram per litre. The content of sodium well within the WHO prescribed limit 200 mg per litre. Potassium value ranges between 2.8 to 17mg/L. All samples are in the WHO recommended limit 15 mg per litre, except sample number N-8 & N-15. The high content of Potassium up to (3700 mg /day) has no harmful effect on the health of individuals, because it is rapidly excreted. Very high content (dose) of potassium results in chest tightness, nausea, diarrhoea, shortness of breath, heart failure, vomiting and hyperkalaemia.

5.10. Sulphate

The content of sulphate in present study water samples is in the range 16 to 375 mg/L. Sulphate is produced mainly by the oxidation process of their ores. Mostly these sulphate ions are soluble in water. They are also present in industrial waste. The quality of sulphate inverter sample was measured by UV spectrophotometer as per IS: 10500- 2012, the prescribe limit for sulphate is 200 milligram per litre and permissible limit is up to 400 mg/L. The sulphate content of all water samples is in the permissible limit.

5.11. Phosphate

Phosphate is an essential natural plant nutrient, most often it controls plant growth. Due to low solubility of native Phosphorus minerals and the availability of soil to retain phosphate, generally ground water contains only a minimum Phosphorus level. The content of phosphorus in drinking water samples is in the range of 0.2 to 2.8mg/L.

5.12. Turbidity

Suspended particles in water interfering with the passage of light called turbidity. It is caused by various types of suspended particles. Turbidity can be found either by its effect on transmission of light which is termed as turbidity or by its effect on scattering of light that is termed as nephelometry. As per IS: 10500-2012, permissible limits are 1 and 5 NTU respectively. All samples are within the range.

VI. CONCLUSION

The present study work is an attempt to analyse the drinking water quality. Most analyse samples are found contaminated either due to one or more parameters. Only pH, sulphate, iron and turbidity parameters are in the permissible range. Some parameters in all samples cross the WHO limit. Arsenic is carcinogenic and is reported in samples as high as 1.154 and 1.518 ppb in N-14 and N-16 Koyal and Nepewala villages. Therefore the presence of arsenic is a serious threat to health. As a result, it is concluded that drinking water must be treated before supply or drinking and other purposes.

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