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PHYSICO-CHEMICAL ANALYSIS OF WATER SAMPLES AND EFFECT OF ITS QUALITY ON HUMAN HEALTH

Atul S. Nagpure[1]*, Nilesh G. Gode[1], Dheerendra S. Singh[2], Anil N. Korpenwar[3]

1. Department of Chemistry, Rashtrapita Mahatma Gandhi Arts & Science College, Nagbhid, Dist-Chandrapur, Maharashtra-441205, India.
2. Catalysis & Inorganic Chemistry Division, CSIR-National Chemical Laboratory (CSIR-NCL), Dr. Homi Bhabha Road, Pune-411008, India.
3. Department of Botany, Rashtrapita Mahatma Gandhi Arts & Science College, Nagbhid, Dist-Chandrapur, Maharashtra-441205, India.

ABSTRACT: The present study is aimed at investigating the concentration of various elements present in water samples of "Navegaon Pandao Village of Nagbhid Taluka in Chandrapur District, Maharashtra state, INDIA". For this purpose, water samples were collected from various sources to study their quality. These samples consist of bore well and normal well water. The Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) instrument was employed for elemental analysis of these water samples. The obtained results were also compared with the standard recommendation values specified by World Health Organization (WHO) for the use of drinking by humans. The concentration of Al, B, Ba, Bi, Cu, Li, Ni, Mn and Zn were found to be lower than WHO limit in all samples. On the other hand Ca, K, Mg, Na and Si were on higher side of acceptable limit in some samples. The present study will be useful to identify the places where water-quality standards are met and will be indicative of the places where the water-quality is below standards. The adverse effect of the elements concentration on the health of the humans is also discussed. The data reported in this report will be extremely useful from the public health point of view.

KEYWORDS: Water; Public health; Elements; Adverse effect.

***Corresponding Author: Dr. Atul S. Nagpure** Ph.D.

Department of Chemistry, Rashtrapita Mahatma Gandhi Arts & Science College, Nagbhid, Dist-Chandrapur, Maharashtra-441205, INDIA. *** Email Address:** atulnagpure43@gmail.com

1. INTRODUCTION

Water is indispensable for the survival of life on earth. Increasing access to safe-drinking water can result in concrete benefits to the human health. As population grows, their need for water enhanced and thus the pressure on our groundwater resources also increases. In many parts of the world, groundwater is being over extracted. This led to falling water levels, diminishing well yield, land subsidence and ecological damage. Although, water has the simple formula ***"H_2O"***, it is an intricate chemical solution. Natural water, whether under the ground, on the ground surface or in the atmosphere, always contains dissolved gases and minerals because of its interaction with the organic matter, minerals in rocks, atmosphere and living organisms.[1] Single mechanism is not adequate to explain the process that are undergoing in the water. Generally, groundwater taste is depends on the type and amount of minerals dissolved in it. Pure water, to be precise, water without dissolved minerals, doesn't occur in nature. The amount of dissolved minerals in groundwater is depends on the following factors: (1) the chemical state of the groundwater; (2) the types of minerals that make up the aquifer and (3) the contact time of water with the minerals.[1,2] Majority of the groundwater comes from rain that soaks into the soil and passes down to the aquifer. Different rocks, for example, basalt, sandstone and limestone all have different minerals and thus groundwater in contact with these different geological materials will have different compositions. Some of the constituents found in groundwater, however, are not abundant in common rocks and minerals, for instance, sulfate (SO_4^{-2}) and chloride (Cl^-). The possible source for these chemicals is rainwater. Most of the natural and seasonal water quality differences we observe are the result of significant changes in the chemical state of groundwater. The chemical state of groundwater is normally defined in terms of three parameters: pH, temperature and redox potential.[2] These aspects are often influenced by the chemical reactions between the groundwater and aquifer materials or mixing with different waters and these factors in turn control the chemical composition of groundwater. The pH is a measure of the acidity of groundwater: the lower the pH, the more acidic is the water. At the typical temperature of groundwater, a pH of 7 is considered neutral. The pH is actually a measure of the hydrogen ion (H^+) availability (activity). The H^+ is very small and is able to disturb mineral structures so that they contribute dissolved constituents to groundwater. As a result, the greater the H^+, the higher the total dissolved solids in the water. The actual concentration of dissolved solids in water is also temperature dependent, e.g., at higher temperatures, groundwater can dissolve more of its minerals. Even changes in groundwater temperature by 5 to 10 °C can cause large changes in total dissolved solids.[2] Redox reactions results in variation of the charge of an ion as it loses or gains the electrons. These reactions are almost always facilitated by the bacteria that are able to gain the energy from the reactions. The solubility of many elements in water depends on whether they are reduced or oxidized. Hence, the natural environment may control in which state the element occurs.

Groundwater is always in contact with minerals and rocks and moves more slowly than surface water, i.e., centimeters per day instead of kilometers per hour. Thus, groundwater often contains more dissolved minerals than surface water.[2] When water percolates below the surface, it passes through the soil where microbial respiration processes release CO_2. As water interacts with the CO_2, the pH is decreased, due to which water can dissolve more minerals. Deep groundwater tends to be warmer (e.g., the source of water from hot springs) and as a result, water has higher mineral content. Information of rock-water-organism reactions helps hydrologists to know the origin of a specific water sample. Systematic analysis of the water samples allows them to identify what types of reactions have affected the water and to understand the geological history of the area. Pollution of groundwater is an injury to water quality by chemicals, heat or bacteria to some extent, which does not necessarily construct an actual public health hazard, but does harmfully affect the water quality such as water for farm, domestic, industrial or municipal use. Many trace elements like Cu, Zn, Fe, Ni, Mn, Co, etc., are very essential for the proper functioning of the biological system and their deficiency or excess in the human can lead to number of disorders.[3-7] However, certain trace elements like Cd, As, Hg, Pb, etc., are known to be persistent environment contamination and toxic to most forms of life.[3] Generally, trace elements are present in small concentration in water system. Their presence in surface water and groundwater may be due to the dissolution of minerals containing trace elements in the soil zone and aquifer. Moreover, human activities such as mining, smelting of ores and improper disposal of industrial waste can also lead to the deposition of toxic elements in water body. The present study is associated with the investigation of elemental concentration in water samples collected from "*Navegaon Pandao Village of Nagbhid Taluka in Chandrapur District, Maharashtra state, INDIA"*. This survey will be extremely helpful for people of *Navegaon Pandao* Village from their health point of view.

2. MATERIALS AND METHODS

2.1. Selection of sites:

Nine water samples were collected from Navegaon Pandao Village. The collected samples were grouped under two categories on the basis of its source: (a) well water (W1, W2) and (b) bore well water (H1, H2, H3, H4, H5, H6, H7).

Sample ID	Sample Name
W1	Churhe Sir
W2	Dadaji Pandao
H1	Bazar Square
H2	Damodhar Navaghade
H3	Khatuji Borkute
H4	Temdev Navaghade
H5	Yuvraj Watkar
H6	Venkatesh Borkute
H7	Motiram Panse

2.2. Procedure adopted for water analysis:

The elemental analysis of water samples was performed using Inductively Coupled Plasma-Optical Emission Spectrometry (**ICP-OES**) technique, model number: Spectro Arcos, FHS-12. The standard solutions containing different elements were used for the calibration purpose (for example calibration curve for Ba element is shown in Figure 1). The water samples were analyzed for the detection of the following elements: Al, As, Ag, B, Ba, Be, Bi, Ca, Cd, Cr, Co, Cu, Fe, Ga, Hg, K, Li, Mg, Mn, Mo, Na, Ni, Pb, P, Sb, Se, Si, Sr, Sn, Te, Ti, Tl, V and Zn. The pH of water samples was measured using pH meter (Eutech instrument, pH Tutor), which was calibrated using standard buffer solutions (pH = 4, 7 and 10). The glass electrode was washed with deionized water after each reading.

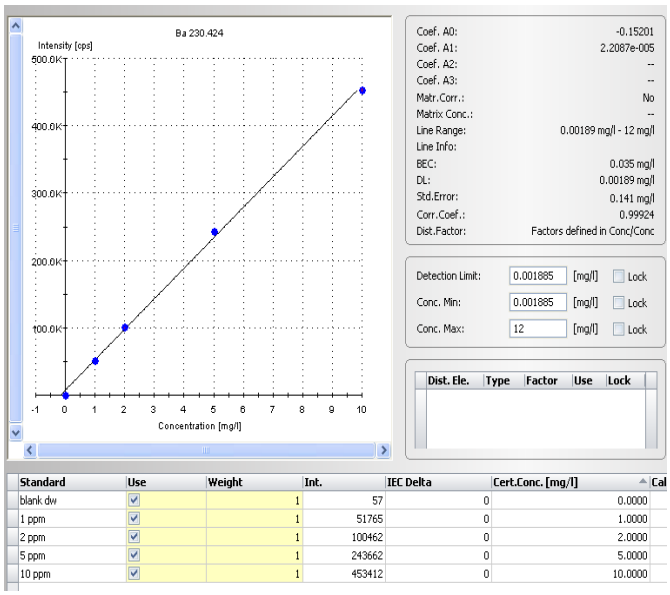

Figure 1. Calibration curve for Ba element.

3. RESULTS AND DISCUSSION

Various elements found in water samples are shown in Table 1 and Table 2. Safety limits of these elements in parts per million (ppm) as per World Health Organization (WHO) were also given for drinking water along with adverse effect of their concentration on living bodies (Table 3).[3] The occurrence of elements in ground and natural water is influenced by hydro chemical factors, like soil features, mineral composition of the rocks, etc., as well as by anthropogenic activities and expected to show both temporal and spatial deviation.

Table 1. Concentration of elements in water samples.

Sample ID	Element concentration (ppm)															
	Al	As	Ag	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	Hg	K
WHO limit	0.2	0.01	0.002	0.3	0.09	0.004	0.07	25	0.003	0.01	0.05	1.5	0.3	0.001	0.001	2.4
W1	0	0	0	0	0.012	0.04	0	47.3	0	0	0	0	0	0	0	24.3
W2	0	0	0	0.03	0.023	0.031	0	58.6	0	0	0	0	0	0	0	69.7
H1	0	0	0	0	0.123	0.011	0	40.0	0	0	0	0	0	0	0	27.0
H2	0	0	0	0	0.03	0.044	0	48.9	0	0	0	0	0	0	0	3.0
H3	0	0	0	0	0	0.042	0	53.0	0	0	0	0	0	0	0	2.2
H4	0	0	0	0	0	0.018	0	45.2	0	0	0	0	0	0	0	1.4
H5	0	0	0	0	0	0.044	0	35.9	0	0	0	0	0	0	0	1.2
H6	0	0	0	0	0.026	0.025	0	70.1	0	0	0	0	0.408	0	0	71.4
H7	0	0	0	0	0	0.044	0	52.7	0	0	0	0	0	0	0	2.1

Table 2. Concentration of elements in water samples.

Sample ID	Element concentration (ppm)																
	Li	Mg	Mn	Na	Ni	Pb	P	Sb	Se	Si	Sr	Sn	Te	Ti	Tl	V	Zn
WHO limit	0.01	15	0.5	50	0.02	0.02	0.02	0.005	0.01	4	0.02	0.002	0.001	0.01	0.001	0.005	3
W1	0	21.8	0	48.8	0	0	1.24	0	0	12.23	0	0	0	0	0	0	0
W2	0	16.8	0	98.3	0	0	1.38	0	0	15.43	0	0	0	0	0	0	0
H1	0	17.7	0	48.5	0	0	2.12	0	0	19.21	0	0	0	0	0	0	0.34
H2	0	25.3	0	24.9	0	0	0.28	0	0	9.45	0	0	0	0	0	0	0
H3	0	29.9	0	24.9	0	0	0.39	0	0	11.54	0	0	0	0	0	0	0
H4	0	28.2	0	93.7	0	0	2.13	0	0	10.82	0.01	0	0	0	0	0	0
H5	0	22.1	0	127.9	0	0	0	0	0	12.33	0	0	0	0	0	0	0
H6	0	18.3	0	107.5	0	0	1.21	0	0	8.23	0	0	0	0.18	0	0	0.02
H7	0	37.8	0	136.2	0	0	1.34	0	0	6.91	0.01	0	0	0	0	0	0

Copper: According to the limits prescribed by WHO authority, copper can be present up to 1.5 ppm, but it was found that its concentration in all water samples collected from different sources was much below the permissible limit.

Iron: Iron is a part of hemoglobin, so it is very essential for all living organism. However, in excess iron promotes bacteria in water. Iron, which is supposed to be 0.3 ppm, was found slightly higher in H6 water sample (0.408 ppm), while it was much lower in all other water samples. Therefore, it is essential to add some amount of Fe mineral in the water, which will make water good for drinking purposes.

Manganese: According to WHO, the maximum acceptable concentration of Mn in drinking water is 0.5 ppm. But, Mn was absent in all water samples.

Lead: It is a very toxic element, which accumulates in the skeletal structure of humans and animals. The maximum permissible concentration of Pb in drinking water is 0.02 ppm. All of the samples drawn from different sources do not contain Pb.

Chromium: The maximum permissible limit of Cr in drinking water according to WHO is 0.05 ppm. Small amount of Cr is essential to mammals but in excess it produces harmful effects. The analysis data shows that no Cr is present in all water samples.

Zinc: Zinc is an essential element to plants and humans. The maximum permissible concentration of Zn in drinking water is 3 ppm. But, the content of Zn in all the water samples is below the requirement.

Calcium: It is a dietary requirement for all organisms. According to WHO, maximum acceptable limit of Ca is 25 ppm. It was found that all the samples contain Ca concentration more than

permissible limit. Drinking water containing higher concentration of Ca may assist in the strengthening bones and teeth.

Potassium: It is a dietary requirement for humans. Some samples (W1, W2, H1, H2 and H6) contain higher concentration of K than that of permissible limit according to WHO (2.4 ppm). Higher K may lead to stomach complaints and nausea.

Magnesium: It is a dietary element required for humans. All the samples contain excess concentration of Mg. Higher Mg may cause muscle slackening, nerve problems, depressions and personality changes.

Sodium: This element is a dietary requirement for humans. According to WHO, maximum acceptable limit for Na is 50 ppm. All the samples contain excess concentration of Na except W1, H1, H2 and H3. Shortage of sodium may lead to dehydration, convulsion and muscle paralysis. However, Na overdose causes increased blood pressure, arteriosclerosis, oedema and confusion.

Table 3. Safe limits in ppm as per WHO for drinking water and adverse effect of their concentration on living bodies.[3]

Element	Safe limit (ppm)	Effect on rising the concentration above safe limit
B	0.3	Causes nausea, vomiting, diarrhoea and blood clotting.
Ca	25	It is dietary requirement for all organisms. Hard water may assist in strengthening bones and teeth because of its high calcium concentration. Metallic Ca corrodes the skin.
Cu	1.5	Astringent taste but essential elements for metabolism, deficiency results is anemia in infants and excess may results in liver damage.
Cr	0.05	Carcinogenic acuity (cancer), can produce coetaneous and nasal mucous membrane ulcer & Dermatitis, hexavalent Cr causes lung tumors.
Fe	0.3	Promote Iron Bacteria in water, bad Taste, In trace is nutritional.
Mn	0.5	Produces bad taste, essential as cofactor in enzyme system and metabolism process. Excess causes reduced metabolism of iron to form Hemoglobin.
Hg	0.001	Causes minamata disease also causes blue baby disease in Infants and the color of skin in baby is turn into blue. Paralysis.
Sr	0.02	Radioactive Sr is carcinogenic and increased infant mortality.
Pb	0.02	Toxic plumb solvency diseases, burning in mouth, several inflammations in gastro intestinal track, causes paralysis, mental confusion, visual disturbance, anemia etc.

Zn	3	Causes Astringent taste & opalescence in water, Essential elements in human metabolism.
Mg	15	It is a dietary for humans. One of the micro elements that is responsible for membrane function, nerve stimulant transmission, muscle contraction, protein construction and DNA replication. Higher Mg may cause muscle slackening, nerve problems, depressions and personality changes.
K	2.4	It is a dietary requirement for humans. K plays vital role in nerve stimulus, muscle contractions and blood pressure regulation. K shortage may lead to depression, muscle weakness and heart rhythm disorder. Higher K lead to stomach complaints and nausea.
Na	50	It is a dietary requirement for humans. Na shortages may lead to dehydration, convulsion and muscle paralysis. Na overdose causes increased blood pressure, arteriosclerosis, oedema, hyperosmolarity and confusion.
Si	4	It is a dietary requirement for humans. Si mainly requires for development of bone. $SiCl_4$ may causes breathing problems and skin irritation.

Exposure to high pH values results in irritation to the skin, eyes and mucous membranes. When pH values more than 11, eye irritation and exacerbation of skin disorders takes place. Moreover, solutions of pH 10–12.5 have been reported to cause swelling of hair fibres. Exposure to low pH values can also result in similar kind of effects. Below pH 4, irritation and redness of the eyes have been reported and the harshness of which increases with decreasing pH value. Table 4 shows the pH data of all water samples. It can be seen that pH of water samples was varied from 7.2 to 8.

Table 4. pH analysis of water samples.

Sample ID	pH
W1	7.3
W2	7.7
H1	7.3
H2	7.2
H3	7.2
H4	7.3
H5	7.7
H6	8.0
H7	7.6

4. CONCLUSION

It is always necessary to monitor the environment for toxic as well as for essential elements in order to understand the correlation of the environment with the biological system. This survey will surely help to have a better idea in taking further steps for possibly enhancing the quality of drinking water in *Navegaon Pandao* Village. Systematic elemental analysis of water samples was performed by using ICP-OES technique. A comparison of the values obtained with the critical values available helps one to have more insight of the problem. The toxic elements like As, Cd, Cr, Hg, Pb, Sb, Se, Sr, Te, Tl and V was found on much lower side than permissible limit. According to the ICP-OES analysis, the Al, B, Ba, Bi, Cu, Li, Ni, Mn and Zn were not found beyond the limit. However, Ca, K, Mg, Na and Si are found towards on higher side in some water samples, but these metals are essentials for our body metabolism. They play key role of co-factor in enzyme activity. "*Based on the elemental analysis and pH data results, all the water samples are strongly recommended for drinking purposes".* Many of the environmental health problems are the result of long-term, low-level exposure to heavy metals as drinking water plays an important role in environment-human health interactions. Thus, to keep ground water free from Cr, Fe, Mn, Cd, Pb, Hg, Sr, Tl, etc., and from other harmful elements or ions, the following suggestions should be taken in to account.

1. Awareness should be generated about the over use of pesticides, its harmful effects on the quality of water and human health.
2. Excessive use of nitrogenous and phosphates fertilizers in agricultural should be avoided, so that it does not leach down to ground water and deteriorates its quality.
3. Industries must set up their effluent treatment plants independently or jointly with other related industries as per norms and should remain efficiently operational in order to preserve the ground water for future generations.
4. Chromium enriched refuge should be suitably treated and then disposed off. Use of ground water near dumping sites or its immediate neighborhood should be avoided as Cr pollution normally relates to point source.

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CONFLICT OF INTEREST

The authors have no conflict of interest.

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