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Analysis of Borewell Water Samples across Raigad and Palghar District

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Abstract: *Ground water quality is increasingly threatened by contamination of both natural and anthropogenic activities. The present work investigates the physiochemical properties and heavy metal contamination of borewell water from different locations across Raigad and Palghar district. Seven water samples were collected from Vicumbhe and Taloja located in Panvel, Amboli and Udhwa located in Palghar, Kalamdevi located in Dadra and Nagar Haveli and from Jyoti Village near Arnala, Virar. The various parameters such as pH, salinity, hardness, Chemical Oxygen Demand (COD), heavy metals using Fourier-Transform Infrared spectroscopy (FTIR) were studied and compared for each sample. The results for pH show variations from 5.70-7.20, with slightly acidic pH recorded for most samples. Salinity readings are almost zero for all samples. Variations in Hardness from 320-760 ppm are observed. Chemical Oxygen Demand has values ranging from 528-816 ppm. These variations maybe due to the varied topography, dissolved nutrients and heavy metals present in the lithosphere, climatic factors, industries surrounding the areas, etc. All these factors play a major role in determining the quality and potability of water. Heavy metals are expected to be present in trace amounts in the water samples but further study is needed to confirm their presence and concentration, which shall be conducted in the near future. These results were compared and the data is recorded in the present work...*

Keywords: Borewell, Water, COD, FTIR

I. INTRODUCTION

Water composing of hydrogen and oxygen, as it's constituent elements are present in the ratio of two is to one (2:1). Water acts as a natural chemical substance which is essential for life on earth [1]. Analysis of borewell water is essential as it is used by many people for drinking and household activities. Borewell water may contain many toxic chemicals, heavy metals, contaminated by biological waste, plastic, etc. Such chemicals and organic waste not only damage the water quality but also harm the aquatic life and show side effects ranging from nausea, diarrhea, etc. in humans. Many harmful elements, like Fe, Hg, U, etc. leach out of plastic and lead to their accumulation in food chain and environment. Heavy metals found in the earth's crust or in the underground water sources are often toxic, carcinogenic, and can bio-accumulate in biological systems throughout the years. They can cause harm to various organs over prolonged use of such contaminated resources. Thus, affecting neurological system, liver, kidneys, etc. even at minimum exposure levels [2].

Various parameters such as pH, salinity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and heavy metal ions are considered to give an account on toxicity and hazards of pollutants present in the aquatic ecosystem as well as the risks of humans consuming such contaminated water.

Parameters Considered are:

1) pH: Also known as potential of hydrogen, represents the concentration of hydrogen ions ($H+$) in a solution and is mathematically expressed as negative log of hydrogen ion concentration. It determines whether the sample is acidic (<7), basic (>7), or neutral (=7).

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2) Salinity: It refers to total concentration of dissolved salts in sea water, expressed as grams of solid materials present per kilogram of seawater. It is determined after replacing all the carbonates with oxides, bromine and iodine by chlorine, and completely oxidizing all organic matter. Salinity provides an estimate of total salt content of aquatic ecosystems and thus is very important for understanding the impact on aquatic organisms.

3) Hardness of Water: Total hardness of water refers to the combined concentration of Calcium and Magnesium salts dissolved in the water sample. Hardness of water can be classified into two types – Temporary and Permanent Hardness. Temporary Hardness arises from carbonates and bicarbonates of Calcium and Magnesium, whereas Permanent Hardness is caused by their chlorides, nitrates and sulphites.

4) Chemical Oxygen Demand (COD): COD represents the amount of oxygen required to chemically oxidize the organic and other oxidizable substances present in the water bodies. It helps determining the amount of dissolved organic pollutants present in milligrams per liter of water.

II. MATERIALS AND METHODS

Borewell Samples were collected from Vicumbhe, Taloja located in Panvel; Amboli, Udhwa located in Palghar; Kalamdevi located in Dadra & Nagar Haveli and from Jyoti Village near Arnala, Virar, and a well sample was collected from Virar. After manually collecting all these samples, they were stored in water bottles of 1lt capacity and brought to college laboratory for experimentation.

Instruments: Refractometer, pH meter, FTIR were used respectively for measuring salinity, pH and amount of heavy metals present in dissolved form in water samples.

Chemicals: Chemicals like EDTA (0.01M), Eriochrome Black-T (EBT indictor), Potassium dichromate ($K_2Cr_2O_7$), Sulphuric acid (H_2SO_4), Ferrous Ammonium Sulphate (FAS), Phenolphthalein, Ferroin, etc. were used.

2.1 pH of water sample

Acidic or alkaline nature of water samples was measured using the pH meter. 25cm^3 of sample was taken in beaker and pH electrode was dipped in it to measure the pH.

Table 1: The measured pH values of water samples:

Samples	**Location**	**pH**
S1	Vicumbhe	6.62
S2	Taloja	5.99
S3	Amboli	5.70
S4	Kalamdevi	5.80
S5	Udhwa	5.73
S6	Jyoti Village	7.20
S7	Virar	6.50

S3 is the most acidic sample with pH of 5.70. Whereas all the samples collected from borewells were mostly acidic except for S6 which is found to be neutral.

2.2 Salinity

Increasing salinity of sea waters around the world is a growing environmental and health concern considering studies from recent years [3]. Salinity of sample was measured by Refractometer. It is a device that measures salinity of liquid samples by using light [4]. The light passes through the sample and measures its refraction. In this device, there is a prism on which a drop of sample is loaded and the cover board is closed. After observing through the eyepiece, we can see a scale on which reading for salinity is seen.

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Table 2: The measured salinity of water samples:

Samples	Salinity (ppt)
S1	0.0
S2	0.0
S3	0.0
S4	0.1
S5	0.1
S6	0.2
S7	0.1

Salinity for the water samples is found to be quite low in all the samples except, the slightly higher salinity of 0.2 ppt found in S6 well water sample from Jyoti Village.

2.3 Hardness of Water:

Hardness of water samples is commonly estimated by complexometric titration against EDTA using Eriochrome Black-T indicator. Total hardness values are typically expressed as calcium carbonate ($CaCO_3$) equivalents in parts per million (ppm) or mg/dm^3.

Table 3: Hardness of water samples:

Sample	Readings			Constant Burette Reading (CBR) (cm^3)	Total Hardness (ppm)
	T1	T2	T3		
S1	1.0	1.0	1.0	1.0	400
S2	1.5	1.5	1.5	1.5	600
S3	0.8	0.8	0.8	0.8	320
S4	1.0	1.1	1.2	1.1	440
S5	0.8	0.8	0.8	0.8	320
S6	1.9	1.9	1.9	1.9	760
S7	1.9	2.0	1.9	1.9	760

Reactions:

$$CaR_2 + Na_2C_{10}H_{14}O_8N_2 \longrightarrow CaC_{10}H_{14}O_8N_2 + 2NaR$$

$$MgR_2 + Na_2C_{10}H_{14}O_8N_2 \longrightarrow MgC_{10}H_{14}O_8N_2 + 2NaR$$

Calculations:

10cm^3 of water sample requires (x) cm^3 of 0.02M EDTA solution.
1000cm^3 of 2M EDTA solution = 200g of $CaCO_3$.
1cm^3 of 2M EDTA solution = 200mg of $CaCO_3$.
x cm^3 of 0.02M EDTA solution = 200*x*0.02 = z mg of $CaCO_3$
10cm^3 of water sample = Z mg of $CaCO_3$
1000cm^3 of water sample = Z*1000/10
= Z*100 ppm

Example:

10cm^3 of water sample requires (1.9) cm^3 of 0.02M EDTA solution.
1000cm^3 of 2M EDTA solution = 200g of $CaCO_3$.
1cm^3 of 2M EDTA solution = 200mg of $CaCO_3$.

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$1.9cm^3$ of 0.02M EDTA solution = 200*1.9*0.02 = 7.6 mg of $CaCO_3$

$10cm^3$ of water sample = 7.6 mg of $CaCO_3$

$1000cm^3$ of water sample = 7.6*1000/10

= 7.6*100 ppm

= 760 ppm.

It is observed that Total Hardness of S6 (Jyoti Village) and S7 (Virar) samples is quite high i.e, 760 ppm.

2.4 Chemical Oxygen Demand:

Chemical Oxygen Demand is a measure used to determine the amount of oxygen utilized to chemically oxidize the organic matter and certain oxidizable inorganic substances such as ammonia or nitrates occurring in aquatic ecosystems. It serves as an indicator of water pollution, particularly in areas affected by industries and mining activities, where surface water may become unsuitable for human consumption due to chemical contamination [5].

COD is widely applied in water quality assessment and wastewater management. It is used to evaluate efficiency of wastewater treatment processes, monitor compliance with discharge standards, and estimate the organic load present in wastewater. Additionally, COD values help in determining the design capacity of wastewater treatment plants for specific locations, where wastewater treatment is needed before releasing it into the environment.

Requirements: Potassium Dichromate ($K_2Cr_2O_7$), Ferrous Ammonium Sulphate (FAS) (0.5N), Ferroin indicator, burette, conical flask, etc.

Procedure:

Take $25cm^3$ of water sample, add $10cm^3$ of $K_2Cr_2O_7$ and add 4-5 drops of Ferroin indicator to it and titrate it against 0.5N Ferrous Ammonium Sulphate.

Observation:

Solution in burette: FAS (0.5N)

Solution in conical flask : $25cm^3$ water sample + 10 cm^3 $K_2Cr_2O_7$

Indicator: Ferroin

End Point: Bluish-green to red

Table 4: COD of water samples

Samples	**Constant Burette Reading (cm^3)**				**COD (ppm)**
	T1	**T2**	**T3**	**(CBR) (A)**	
S1	4.1	4.1	4.1	4.1	688
S2	4.3	4.3	4.3	4.3	656
S3	5.1	5.1	5.1	5.1	528
S4	3.8	3.8	3.8	3.8	736
S5	4.0	4.0	4.0	4.0	704
S6	3.5	3.5	3.5	3.5	784
S7	3.3	3.3	3.3	3.3	816

Blank Titration (B):

Distilled Water	**T1**	**T2**	**T3**	**CBR**
	8.4	8.3	8.5	8.4

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Calculations:

Normality of FAS = 0.5N = C

COD = (B-A) *C*8000/25 ppm

COD = (8.4 – 3.3) *0.5*8000/25 ppm

= (5.1) *0.5*8000/25 ppm

= 816 ppm

On calculating COD values of water sample, S7 has the highest value of COD i.e, 816 ppm. This indicates that the water sample contains higher levels of oxidizable materials. As more oxygen is consumed in decomposing the organic matter, the dissolved oxygen level in water is reduced and can be environmentally damaging to the aquatic life forms.

Fourier-Transform Infrared spectroscopy (FTIR):

The water samples were analyzed for presence of heavy metals via FTIR Spectroscopy. FTIR spectroscopy gives the spectra of wavelength that correspond to molecular vibrations caused due to the possible interactions between matter and electromagnetic radiations [6]. It uses Infrared light which is passed through the sample, it gives data according to the corresponding wavelengths emitted by molecular vibrations of atoms and functional groups present in the sample. The peaks and dips on the graph indicate the presence of various compounds. Each peak or dip corresponds to the respective functional group or element. The FTIR graph is plotted as % Transmittance (%T) on Y-axis against wavenumber on X-axis. Higher the %T lesser is the absorption and lower is the %T stronger is the absorption. Thus, the dips in the spectra show the regions with strong absorption.

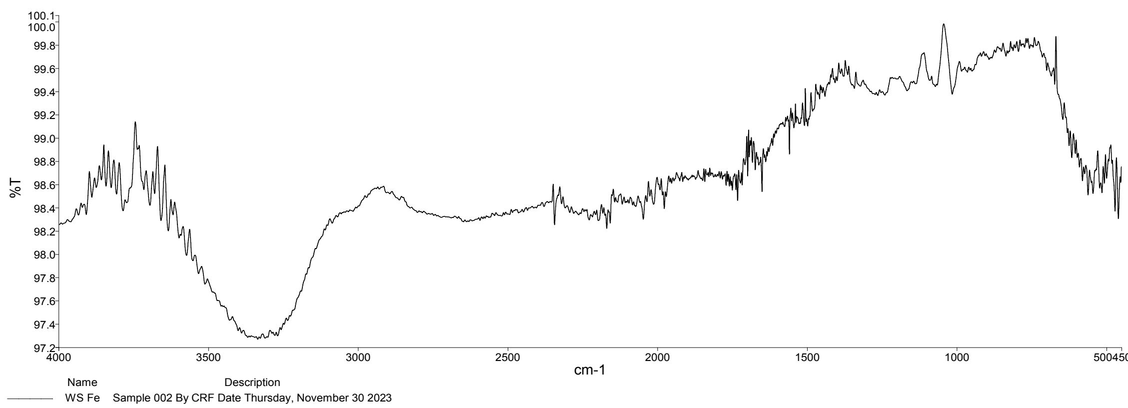

Fig 1: FTIR Graph of control sample containing heavy metals

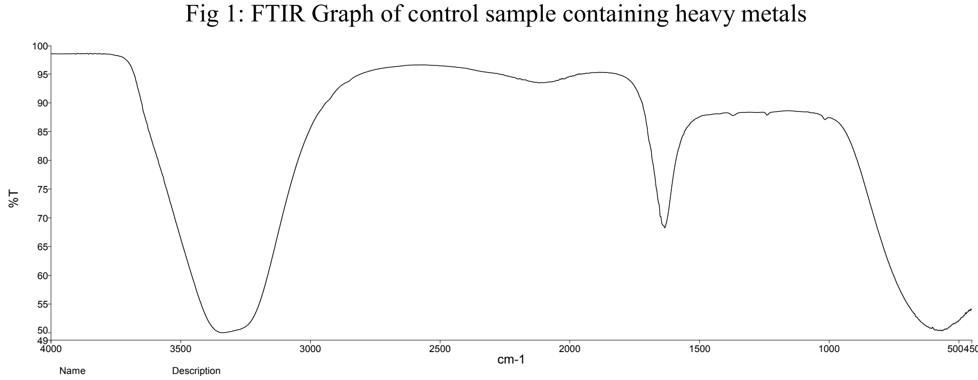

Fig 2: FTIR Graph of water sample 1, without presence of any heavy metals.

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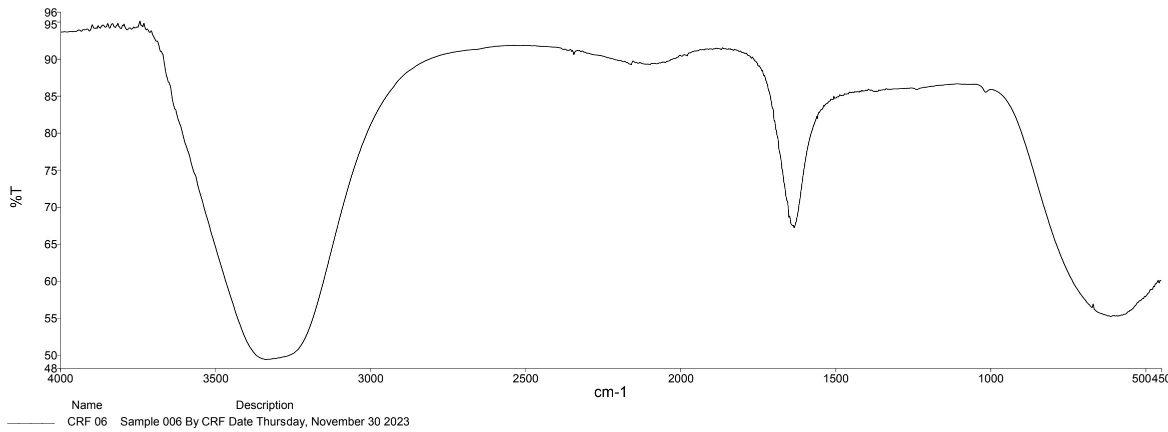

Fig 3: FTIR Graph of water sample 3, with presence of heavy metals in trace amounts.

The control sample contains heavy metals whereas the water samples have unknown contents. From the spectra obtained for control sample, we compared the spectra of other water samples and found out that heavy metals may be present in trace amount, but they cannot be confirmed by just FTIR, higher grade tools like AAS are required for the same.

III. RESULTS AND DISCUSSION:

According to all the tests performed pH of water samples from different borewell locations are in the range from 5-7, which are from slightly acidic to neutral. This finding suggests that the slightly acidic pH of these samples may be due to dissolved salts or other inorganic substances present in water bodies. The acidic pH is usually harmful to the microflora of the water bodies, sensitive algal species or other aquatic life forms. Salt content is negligible in all samples, which indicates good water quality where dissolved mineral content is low. Hardness ranges from 400-760 ppm, indicating the presence of Ca and Mg salts in water, which is mostly responsible due to limestone and dolomite rocks present in the earth's crust [7]. Higher hardness of water may cause skin irritation, scalp irritation, hair fall and difficulties in lather formation while using soap. Water hardness can also be removed by ion exchange using resins, reverse osmosis, boiling water, adding washing soda, etc. Now a days water purifiers are used to filter water for drinking and washing purposes.

COD values vary from 688-816 ppm, indicating contamination due to human activity or industrial wastewater. Any value for COD greater than ~500 ppm is an indicator for presence organic matter in water and higher oxygen demand. COD is an important indicator of total dissolved solids present in an aquatic ecosystem. When COD increases, the dissolved oxygen level in water decreases as the organic matter consumes bioavailable oxygen to get oxidized and thus can be environmentally damaging to the aquatic life forms. The oxygen consumed by the organic matter for it's oxidization results in reduced levels of oxygen for other aquatic organisms often resulting in their death. Increasing water pollution levels is a global concern affecting yield for fisheries industry.

For detection of heavy metals and impurities in the borewell water samples, FTIR was used. The FTIR utilizes Infrared light beam which passes through the sample and the absorption spectra of the sample is displayed on screen. The molecular vibrations of atoms and their bonds are measured. The FTIR graph is plotted as % Transmittance (%T) on Y-axis against wavenumber on X-axis. Higher the %T lesser is the absorption and lower is the %T stronger is the absorption. Thus, the dips in the spectra show the regions with strong absorption. Like the stretching (broad downward dip) between ~3200-3500 cm^{-1}, in Fig 2 indicates strong absorption by Hydroxyl (-OH) functional group. The distinctive dip from ~1600-1650 cm^{-1} exhibits the H-O-H bending vibration and is the characteristic liquid water, thus confirming the presence of H_2O. The downward dip between ~1500-2000 cm^{-1} is of keto functional group (-C=O). The fingerprint region is from ~500-1000 cm^{-1} which shows other restricted movements of water molecules. Heavy metals

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cannot be directly detected by FTIR, but the molecular vibrations of their bonds with other atoms can be detected. The control sample was a synthesized compound containing iron as one of it's constituent element. The compound was dissolved in water and the aqueous solution was used. In the control FTIR spectra Fig 1, we can see the dips and peaks in the region from ~450-700 cm^{-1}, this shows the presence of stretching vibrations for the Fe-O bonds. Other regions of the spectra are similar to water, where we can see the broad stretching from ~3200-3600 cm^{-1} that corresponds to O-H bonds. While dips between ~1600-1800 cm^{-1} corresponds to H-O-H bending vibrations. It may also include some other interactions of the Fe compounds with the water in the regions from ~1500-2500 cm^{-1}. There is slight interference or fluctuations in the Fig 3, in region from ~1000-1500 cm^{-1}, also we can see the dip in both Fig 2 and Fig 3 from ~450-700 cm^{-1}, this may be due to interactions of trace amount of heavy metals or other impurities present in water sample but they cannot be confirmed only by FTIR. Higher grade instruments like Atomic Absorption Spectroscopy (AAS) are required to confirm the presence of heavy metals. As these metals may be present in trace amounts, it becomes difficult to determine them and their concentrations.

The spectra obtained for all the seven samples were similar to each other, with a stretching vibrations of hydroxyl group from ~3200-3600 cm^{-1}, and H-O-H bending vibrations from ~1600-1800 cm^{-1}, the two figures (Fig 2 and 3) displayed here are similar to the other spectra obtained. The Fig 3 is slightly different due to the fluctuations observed from ~1000-1500 cm^{-1}, which may be due presence of impurities or interference from heavy metals which might be present in trace amounts but not clearly detected here. Thus, we can say that the water samples don't contain any prominent heavy metals beyond detection levels, so water can be considered safe in that regard, but further studies are needed in this aspect. Heavy metals cause various problems like neurological impairment, cardiac diseases, kidney problems, etc. after prolonged exposure. It also causes bio-accumulation in environment via food chains and thus are harmful to the ecosystem.

IV. CONCLUSION

The parameters taken into consideration while performing the research are important as it is a deciding factor for the use of water from the above-mentioned resources, in order to spread awareness regarding the same. The lower values of pH make the water acidic, indicating it's contamination by anthropogenic activities or by external environmental factors like acidic rain, organic acids from decomposing vegetation, geological activities of earth's crust, etc. Increased acidity of water in drinking water sources, induces the reabsorption of Ca and Mg from renal tubules in kidneys [8]. Salinity is low in all samples. Thus, indicating good quality of water and lesser dissolved minerals. Hardness of water is high in some samples indicating the occurrence of calcium and magnesium salts. Thus, lather doesn't form on soap while using hard water. Continuous use of such water may lead to dry skin, digestive issues, skin irritation, scalp irritation, etc. Higher value of COD in some samples indicate the possible threat of contamination of water sources by various human activities and chemical effluents from industries. Thus, that makes the water less potable for drinking. As unavoidable waste generation contributes to environmental degradation, the development of sustainable technology for the remediation of pollution sources becomes crucial for ensuring protection and safety [9]. Heavy metals were not clearly detected in samples as FTIR doesn't give direct peaks for heavy metals, instead it gives the molecular interactions between atoms. Heavy metals along with some impurities may be present in trace amounts in the sample as some fluctuations are observed in the spectra. Further studies with advanced instruments are needed to confirm their presence and concentration levels in the samples. If the level of heavy metals increases up to a certain limit then, it may lead to bio-accumulation in the environment over a period of time. It also increases the risk of heavy metal toxicity after the consumption of such water or vegetables grown using the contaminated water. Further analysis regarding the concentration of heavy metals and industrial contaminants in the water resources, their impact on the life of people in the surrounding areas need to be studied and continued in the future.

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