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PHYSIOCHEMICAL PARAMETERS OF JAR BOTTLED WATER AVAILABLE IN REWA CITY OF MADHYA PRADESH

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ABSTRACT

The public perception and probably the reality is that bottled water is regularly of high quality. This belief is encouraged by publicly reported problem of municipal tap water as well as the public perception of purity driven by advertisements and packaging labels featuring pristine glaciers and crystal clear mountain springs. However, many studies have shown that these beliefs need not always be true. A four-year study conducted by the National Resources Defense Council (NRDC, 1999) revealed that about one-third of the samples contained significant contamination, including synthetic chemicals, bacteria and arsenic, in at least one sample, out of more than 1000 samples of 103 bottled water brands tested. It also concluded that "an estimated 25% or more of the bottled water is really just tap water in bottle- sometimes further treated, sometimes not". Even with limited independent testing done for bottled water, problems are periodically discovered. Many individual researches and studies in developed countries have shown that only because water comes out of a bottle doesn't mean that it is definitely purer and safer than the tap water. Similarly, in the words of NRDC, "While much tap water is indeed risky, having compared the available data, we conclude that there is no assurance that bottled water is any safer".

INTRODUCTION

Water resources occupy a special place among natural resources. Water is the basis of life on earth; it is the main component of the environment and essential constituent for human life. Water is also fundamental for sustaining a high quality of life, and for economic and social development. Just like other natural resources, water resources are limited at any location on earth at any time, and they should be used rationally for sustainable development. Since the greater portion of the total freshwater resources (68.7%) is in the form of ice and permanent snow cover in the Antarctic, Arctic and mountainous regions, they are inaccessible for human use. Groundwater comprises 29.9% of freshwater resources[1-5]. The amount of freshwater concentrated in lakes, reservoirs and river systems is the most accessible for human use. Surface water resources provide for more than 70% of the total water demand. Major surface water resources are the river systems. Earth's water turnover depends on water storage and dynamics of storage. This storage dynamics is estimated by the period of full replenishment. The uneven distribution and differing climatic regimes influence the accessibility of water resources. Population growth and urbanization exert heavy demand on water resources. Surface as well as groundwater resources are under the threat of contamination. Accessible water resources also include the yearly renewable groundwater that is not drained by rivers. In certain regions of the world the groundwater resources are the main provider to water needs. In certain areas even though groundwater sources are available, their tapping is economically not feasible. Globally total water abundance is not the problem; the problem is water availability in the right place in the right time in the right form with right quality. Ambitious programmed for diversion of fresh water from areas of abundance (Polar Regions, high mountain ranges) to areas of scarcity are proposed. But the cost of such plans is exorbitant and prohibitive.

The city Rewa is located on northeast part of eastern M.P. having two rivers *Bichhiya* and *Behar* and one main pond/*talab* named *Rani Talab* located in the heart of city. The Bank of river *Bichhiya* and *Behar* accommodates larger part of city dwellers. The municipal area of city comprises 45 administrative ward and cover the area of 6927 hectare and having population of 235422 with a projected population growth of 4 to 5 percent yearly. Industrial development in

Rewa city is increasing day by day apart from this being a divisional head quarter of the administration various educational institute of learning of higher education in all field, the influx of families from surrounding area are also considerably increasing. Before the reorganization of the state Rewa was the capital of Vindhya State, hence this city is historically and religiously important for the people of Vindhya region. Hence, due to industrial development and population growth, the rivers pond, *talab* and other urban surface water are becoming more and more polluted. Meanwhile, the detergents are also playing an important role toward enhancing pollution. Detergent in wastewater comes from residence in the form of household detergent, agriculture runoff in the form of herbicides and insecticides and from certain industries. Rewa city does not have proper drinking water treatment and supply system. Tap water and public water sources are generally contaminated but still essential, and those without other resources rely on local surface water mainly the *Bichhiya* and *Bihar* River/*Rani talab* for bathing washing, drinking and as a public toilet. Furthermore, the River and Pond/*talab* has become a sewage discharge site for municipal wastewater and industrial dumping ground for local business with no other means of disposal. The municipal water supplies are inconsistent and unreliable. Not only the shortages in quantity, but also the compromised quality of municipal tap water has become a major public health issue. Throughout Rewa city, people are exposed to severe health threats resulting from water contamination by sewage, agriculture and industry. Owing to the impact of sewage, typhoid, dysentery, and cholera are endemic every summer (Khadka, 1993). These diseases account for 15% of all illness and 80% of total deaths, but those number increases to 41% of all illness and 32% of all deaths in children up to 4 years (Sharma, 1990). Diarrhoeal diseases are recorded as the second most prevalent disease in Rewa city. According to Sharma, 2003, around 75 children die each day from diarrhea alone. Recently, the diarrhoeal epidemic that affected us more concerned about the drinking water quality. Although being the dwellers of the city, we are neither in the state to proclaim proudly that the water we use is any purer nor can it be guaranteed that these kinds of epidemics can't occur in the city. Thus, conveying message to the public about water quality and sanitation and at the same time, using disinfectants to purify water is a must in the present scenario. In the context of growing health consciousness and chronic water shortages, most of the urban residents have switched to bottled water as a safe alternative[6-20].

Bottled Water in Rewa city:

The history of bottled water in Rewa city can be dated before 1990 when Bisileri Water was the only brand available. Subsequently, since then, the numbers of bottled water companies have been increasing. According to the recent data provided by Company Registrar's Office, there are 10 companies of bottled water registered in Rewa city out of which only few have received NS Standards.

PET bottles of 1 liter and jars of 20 liters are available in the market. The price of PET bottles of 1 liter ranges from Rs.15-30 whereas for jar water ranges from Rs.100-750 with refilling price ranging from Rs.45-150. PET bottles are discarded after use while jars are taken back to the related companies and refilled. Jar water are commonly used for household purposes as well as in offices, educational institutions and restaurants.

STATEMENT OF THE PROBLEM:

Water quality has a direct impact on public health. More than 80% of deaths are caused due to water borne diseases. The water supply system in Rewa city is insufficient as per demand of consumers due to centralization of population day by day. The people of Rewa city show an increasing trend of using jar water, mostly driven by the unreliable and quality compromised tap water supply and in part due to the perception and expectation of pure and safe drinking water. With the increasing demand and insufficient supply, it seems that in the near future, the urban dwellers would not have an option other than using bottled/jar water. Thus, it is high time to check the quality and monitor the bottled water industry. However, very few studies have been carried out to assess their quality and there are no agencies that regularly monitor their quality.

In present study I have chosen following bottled/ jar water companies to studies have been carried out to assess their quality:

1. Roshani jal , Near rani Talaab, Rewa(M.P.)
2. Amrit jal, Uddyog vihar, Chorahata(Rewa)
3. Malti jal, Sirmour chauraha Rewa (M.P.)
4. Nirmal jal, Transport nagar, Padara Rewa (M.P.)

Safe drinking water is a fundamental right of human being. However, is the water that we drink safe? The answer is obviously "NO" as shown by the death statistics from

water borne diseases which accounts to 80%. Driven by the perception of purity, people switch to buy bottled water. The question is not: why to check the quality of bottled water, it is: why not? People have the right to know the quality of water that they perceive to be pure. Hence, this case study is justifiable.

METHODOLOGY

Samples of four brands of jar water of 20 litres capacity were collected randomly from various restaurants as well as from jar water selling shops. For analysis of physicochemical parameters, water sample was collected in PVC sampling bottle. Some parameters such as temperature, pH, chloride, dissolved oxygen (DO), hardness, alkalinity and free carbon dioxide were determined in site while other parameters were determined in the laboratory of Govt. T.R.S. College, Rewa (M.P.). For determination of iron contents, about 1ml conc. HCl was kept in the samples bottles before the collection of water sample, in order to preserve the samples in reduced state. Samples for bacteriological analyses were collected in sterilized bottle, stored in ice cold box and transported to laboratory and were processed within 6 hours of collection.

SAMPLING FREQUENCY:

Water quality was analyzed twice for each brand of bottle water during months of January, February and March when the difference in daily temperatures and change in season proceeds. The methodologies used to analyze various parameters are described below.

ANALYSIS OF WATER SAMPLES

"Standard Methods for the examination of water and wastewater", (APHA, 1998) was followed to analyze most of the physicochemical parameters of water[21-23].

RESULT AND DISCUSSION

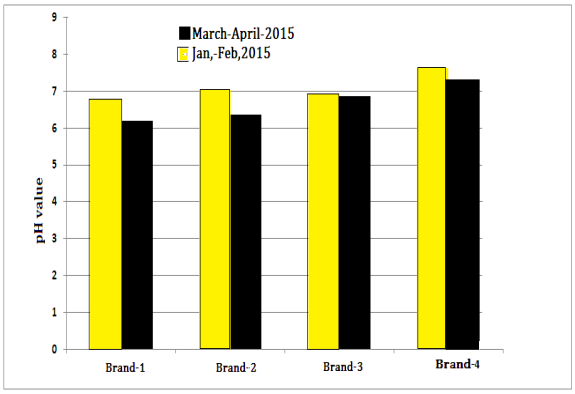
The analysis of sample of drinking jar water supplied by four major brands in Rewa city of Madhya Pradesh being done at the chemical laboratory, department of chemistry Govt. T.R.S. College, Rewa . The various results of the drinking water quality of all brands are recorded in the tables:

Sample(A) / Parameters	Brand 1	Brand 2	Brand 3	Brand 4
pH	6.78	7.03	6.93	7.63
Temperature(° C)	**18**	**20**	**20**	**19**
Conductance	175	60	65	613
Alkalinity (mg/L)	55	20	23	55

Hardness (as $CaCO_3$)	36	18	36	68
Ca-hardness (as $CaCO_3$)	30	10	18	42
Mg-hardness (as $CaCO_3$)	6	8	18	26
Free CO_2 (mg/L)	0	0	0	0
Chloride(mg/L)	27.04	10.42	2.84	86.62
DO(mg/L)	7.5	7.9	7.7	8.2
Iron (mg/L)	0.05	0.04	0.05	0.05
Nitrate A(mg/L)	0.01	0.01	0.01	0.02
Phosphate(mg/L)	0.17	0.15	0.14	0.16
Ammonia A(mg/L)	0.01	0.01	0.01	ND

Sample(B) / Parameters	Brand 1	Brand 2	Brand 3	Brand 4
pH	6.21	6.36	6.87	7.23
Temperature(° C)	**26**	**27**	**25**	**25**
Conductance	150	20	15	815
Alkalinity (mg/L)	45	16	15	52
Hardness (as $CaCO_3$)	46	35	39	60
Ca-hardness (as $CaCO_3$)	30	10	18	42
Mg-hardness (as $CaCO_3$)	6	8	18	26
Free CO_2 (mg/L)	0	0	0	0
Chloride(mg/L)	14.04	11.22	2.94	6.62
DO(mg/L)	7.7	7.7	7.7	8.2
Iron (mg/L)	0.03	0.04	0.05	0.09
Nitrate A(mg/L)	0.01	0.01	0.01	0.02
Phosphate(mg/L)	0.17	0.15	0.14	0.16
Ammonia A(mg/L)	0.01	0.01	0.01	ND

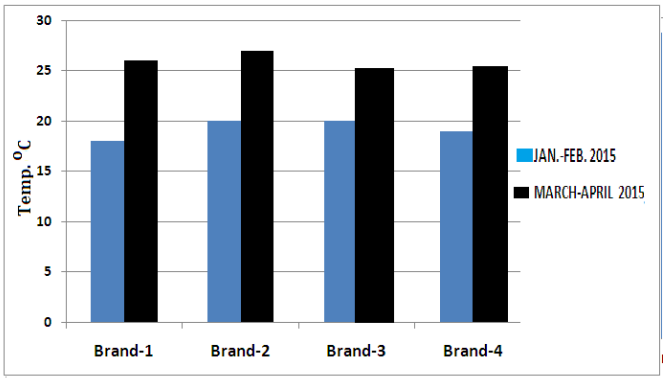
pH: pH is the negative logarithm of hydrogen ion concentration. It is used to express the intensity of acidic or alkaline condition of a solution. The pH values in all the samples tested during Jan / Feb. and Feb. / March range from 6.5-7. pH of pure water is 7.



pH is an extremely important variable because it is the controlling factor determining the solubility of most metals and also because most micro-organisms can survive within a narrow range of pH. pH is also an important factor in water treatment. Proper chemical treatment of water including disinfection requires pH control. The values of pH obtained are within the WHO standards of 6.5-8.5.

Temperature:

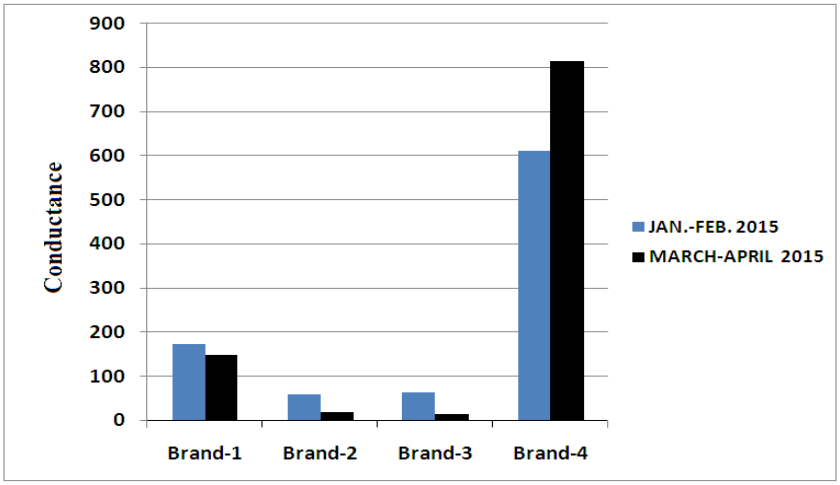
Temperature of fresh water varies normally from 0 to 35ºC depending on the source, depth and season. The temperature of water affects some important physical properties and characteristics of water such as density, viscosity, conductance, salinity, solubility of dissolved gases etc. In addition, chemical and biological reaction rates increase with temperature.



In the above graph, the temperature in the first test during January/February shows range between 15-20 ºC and in the second test conducted during February/March, the ranges are between 19-26 ºC.

Conductance:

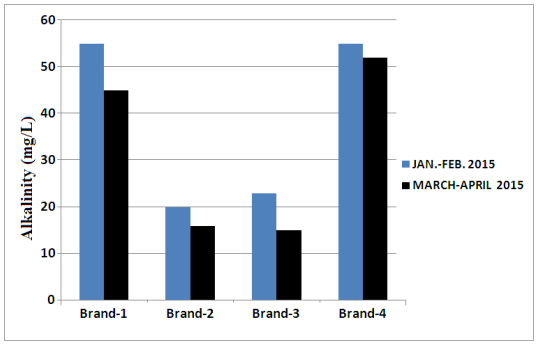
Electrical conductivity is the measure of the capacity of water to conduct electric current.



The values of conductance range from a minimum of 60µs/cm for brand 2 to a maximum of 613µs/cm for brand 4 in first test. Similarly, in the second test, minimum value is 15µs/cm for brand 3 and maximum value is 815 µs/cm for brand 4. In comparison of other brands, brand 4 has high conductance. High values of conductance indicate high dissolved gases and other chemicals in the water. There is no guideline value for conductivity; however, values above 400us/cm may affect the chemical quality of drinking water.

Alkalinity:

Alkalinity is also a major parameter affecting water quality that mainly acts for pH neutralization. Alkalinity measurements are used as the means for evaluating the buffering capacity of water.

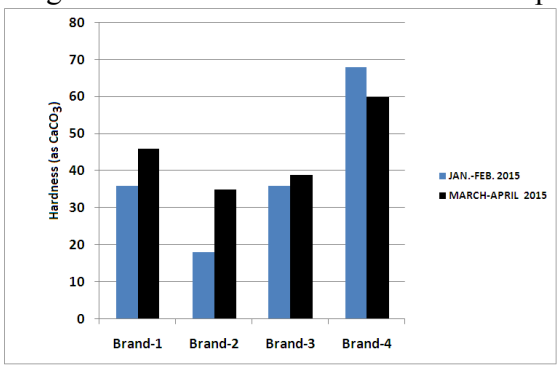


The minimum values of alkalinity were minimum 20mg/L for brand 2 and 55 mg/L for brand 1 and 4 in the 1st and 2nd tests respectively, while the maximum values were 55 mg/L for brand 1and 4 are for in the 1st and 2nd tests respectively. These values are well below the permissible limits. However, there is an increasing trend of alkalinity values. In natural water, most of the alkalinity is caused by CO_2. Since the concentration of free CO_2 also has increased in the second test, the decrease in the values of alkalinity in the 2nd test seems to be obvious.

Hardness:

Hardness is imparted to the water mainly by calcium and magnesium ions. Calcium is essential element for human beings (nearly 2 gm per day) and plant growth. However, hard water is generally undesirable because it forms precipitate with soap, produces scales in boilers on heating and has high boiling point due to which it is unsuitable for cooking. The minimum

values of total hardness was2 mg/L for in the 1st and 2nd tests respectively, while the maximum values were 68 mg/L for brand 4 in 1st and 60 mg/L in 2nd tests respectively. The WHO standard for hardness is 200mg/L. Thus all the values are within acceptable limits.

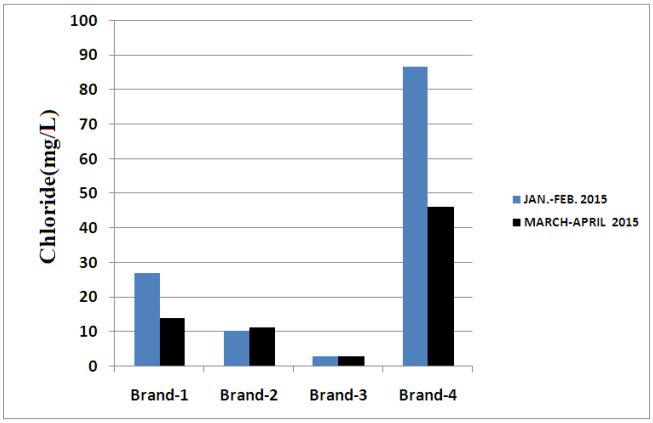


Free CO_2 :

Surface water normally contains less than 10mg/L of free CO_2 while some ground water may contain 30-50mg/L of free CO_2. High concentration of free CO_2 indicates pollution from domestic sewages and industries. However, there are no prescribed limits of free CO_2 for drinking water, as free CO_2 do not bring about physiological effects. The values for free CO_2 for most of the samples are zero in the 1st test.

Chloride:

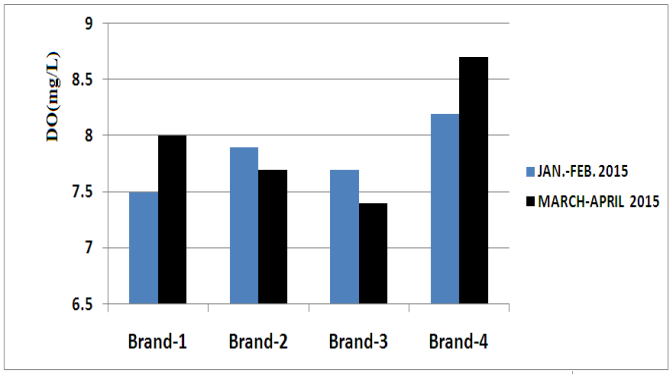
Chloride is present in appreciable amounts in all natural water. Concentration varies from few milligrams to several thousand milligrams per liter. High concentration of Chloride may indicate pollution of organic origin, as well as results in corrosives and impaired taste. The permissible limit of chloride according to WHO is 250 mg/L. Drinking water is often chlorinated for disinfection.



The concentration of chloride is high for brand 4 in both the months. The values of chloride range from 1.42-86.62 mg/L in the 1st test and 8.52-86.02 mg/L in the 2nd test. All the values are within WHO guidelines.

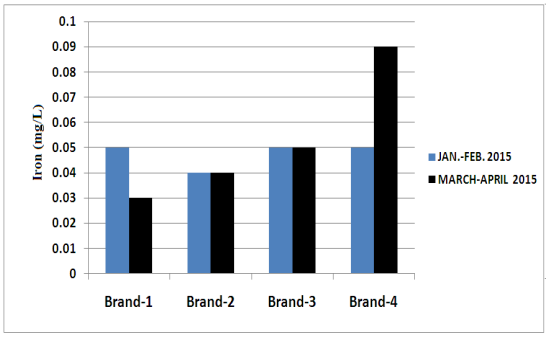
Dissolved Oxygen (DO):

Oxygen is dissolved in water in varying concentrations. It is a very important water quality parameter and is an index of physical and biological processes going on in water. Analysis of DO is very important in water pollution control.



The guideline value for DO is > 5 mg/L according to WHO. Brand 4 shows higher DO values among all. The obtained values are in the range 7.7-8.2 mg/L in the 1st test and 6.9-9.3 mg/L in the 2nd test, which satisfy WHO standards.

Total Iron:



Iron has a little concern as health hazard, but it still is considered as a nuisance in excessive quantities. High iron content produces bitter and astringent taste. The WHO has set the permissible limit of iron to 0.3 mg/L. Among all brands, brand 4 has the highest iron concentration in both the months.

The values of iron range from 0.014-0.1 mg/L in the first test to 0.015-0.12 mg/L in the 2nd test which all lies below the acceptable limits.

Nitrate- N:

Nitrates are present in trace amounts in surface water but in some ground water, nitrates may be high. High nitrite and nitrate concentration in water causes a disease called methemoglobinaemia. In drinking water, nitrate concentration should be less than 10 mg/L according to WHO. The values obtained are in the range of 0.01-0.02 mg/L in both tests, all below the permissible limits.

Phosphate-P:

However, in low concentration, phosphate is an important nutrient present in water. The values of phosphate range from 0.14-0.32 mg/L in the first test and 0.15-0.29mg/L in the 2nd test. The highest value of phosphate is seen for brand 3 in both the months.

Ammonia-N:

Ammonia is generally an indication of pollution in drinking water. According to the guideline value given by WHO, the concentration of ammonia should be 0 mg/L. The maximum

concentration of ammonia was found to be 0.01 mg/L and in most of the test was undetectable, that means, less than 0 mg/L.

Bacteriological examination:

Table: 3
Bacteriological examination water during January/February

Brands	**Presumptive count/100 mL Total Coliforms**
1	210
2	>1100
3	210
4	Nil

In the presumptive count, out of four brands, one brand was found to be contaminated with coliform. Brand 4, was found to have no contamination.

Table 4

Bacteriological examination water during February/March

Brands	**Presumptive count/100 mL Total Coliforms**
1	210
2	>1100
3	210
4	Nil

In this test, only one brand was found to be devoid of both total and fecal coliform while two other brands showed total coliform but no fecal coliforms and the rest brands showed both total and fecal coliform. Among the samples, brand 2 was found to be heavily contaminated.

Data Analysis:

Analysis of physicochemical parameters during January/February showed that the pH of the samples range from 6.55 to 7.63. Temperature of the samples range from 16-18°C. The values of conductance range from a minimum of 60µs/cm for brand 2 to a maximum of 613µs/cm for brand 4 in first test. Similarly, in the second test, minimum value is 15µs/cm for brand 3 and maximum value is 815 µs/cm for brand 4. In comparison of other brands, brand 4 has high conductance. High values of conductance indicate high dissolved gases and other chemicals in the water. There is no guideline value for conductivity; however, values above 400us/cm may affect the chemical quality of drinking water.

The value of alkalinity was also found to be variable. It ranged from a minimum of 10 mg/L for brand 2 to 90 mg/L for brand 4. The values of hardness range from 10 to 68(as $CaCO_3$). The values of Free CO_2 were found to be 0 in most of the brands The values of chloride were also highly variable. The value was below 10 mg/L for 4 brands and a maximum of 86.62 mg/L was obtained for brand 4. The values of DO were more or less similar and ranged from 7.7 - 8.2 mg/L. The value of iron was obtained in a range of0.04-0.05 mg/L. The values of nitrate

obtained were in the range of 0.01 - 0.02 mg/L. Similarly, the values of phosphate were in the range of 0.14 - 0.32 mg/L. Ammonia was not detected in any of the samples.

During Jan/Feb, only three samples of brands 4, has no coliforms at all. That means 66% of the sample is heavily contaminated. According to the WHO limit for the Presumptive count, greater than 10 presumptive count/100mL are unsatisfactory. Due to unforeseen circumstances as well as physical constraints, completion of MPN test was hindered.

Similarly, Analysis of physicochemical parameters during February/March showed that the pH of the samples range from 6.81 to 7.89. Temperature of the samples range from 19 -23°C. Conductance was found to be as low as 70µs/cm for brand 3 and as high as 768 µs/cm for brand 4. The value of alkalinity was also found to be variable. It ranged from a minimum of 25 mg/L for brand 3 to 142 mg/L for brand 2. The values of hardness range from 8 to 76(as $CaCO_3$).The values of Free CO_2 was found in a range between 6.6 - 48.4 mg/L. The values of chloride were 8.52 mg/L for brand 1 and a maximum of 93.72 mg/L was obtained for brand 4. The values of DO ranged from 6.9 – 9.3 mg/L. The value of iron was obtained in a range of 0.05-0.07 mg/L which showed a value of 0.12 mg/L. The values of nitrate obtained were in the range of 0.01 - 0.02 mg/L. Similarly the values of phosphate were in the range of 0.15 - 0.29 mg/L. Ammonia was not detected in any of the samples. During Feb/Mar, with the onset of summer, the MPN count/100 mL has also increased. Total coliform was found to be nil, whereas fecal coliform were found to be nil in 3 samples, this may be partly because of increased microbial activities with the onset of summer or due to the contamination of jar. Even two jars of same brand may vary in quality since during refilling and processing, contamination may occur. Similarly, there is no assurance whether these jars are even processed. The results show that the samples are heavily contaminated with coliforms. It may be due to the improper water processing techniques as well as jars. Furthermore, the source of jar water is not mentioned in any of the jars.

CONCLUSION:

Hence, from the above results, it can be concluded that jar water, although thought to be pure, cannot be relied upon for its safety. Various physio-chemical parameters like DO, hardness, total iron, phosphate, nitrate, ammonia, alkalinity, pH, etc were analyzed using standard methods of APHA (1998). All the Physio-chemical parameters like DO, hardness, alkalinity, pH were within WHO acceptable limits. Ammonia was detected in some samples but is within the limits set by WHO. Iron and Nitrates were found in small quantities but within the limits set by WHO. With the onset of summer, the concentration of some parameters rose like Free CO_2, conductance, alkalinity etc, which are more or less affected by temperature. Thus from the physio-chemical aspect, the quality of water is good.

From the microbiological point of view, 66% of the total samples were heavily contaminated with total coliforms in the first test during January/February. Three brands of jar water tested had no coliforms at all. During the second test in February/March, 89% of the total sample was found to be contaminated with total coliforms whereas 66% were

contaminated with fecal coliforms. Total coliforms as many as 1100 MPN/100mL and a maximum of 20 MPN/100 mL of fecal coliforms were enumerated. Hence, it can be concluded that the water samples are heavily contaminated with coliform bacteria and unsatisfactory for drinking purpose.

As per the NRDC (1999) result says, "While much tap water is indeed risky, having compared the available data, we conclude that there is no assurance that bottled water is any safer." Similar is the conclusion of this study, that there is no assurance that since water comes out of a bottle does not mean it is free from contamination.

5.2. RECOMMENDATIONS:

1. There are varieties of jar water and their quality varies. Thus, it is necessary to pick up the right brand.
2. Stricter rules should be made and implemented to regularly monitor the bottled water qualities.
3. The labels of bottled water must include not only the pristine glaciers and Himalayan springs but also the relative concentrations of water quality parameters.
4. Since jar water are reused, sometimes they are used up to the extent that there is neither company name nor any labels. In such condition, the jar may itself contaminate the water although the water is safe.
5. All the bottled water companies should fulfill the basic water quality standards given by the Government of India and then registered to NS Standards since only three companies have done it so far.
6. Awareness should be created to public for either using disinfectants or boiling water before use rather than rely on the belief of purity.

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