ANALYSIS OF THE PHYSICO-CHEMICAL AND BACTERIOLOGICAL PARAMETERS OF BOTTLED WATER AVAILABLE IN BHANDARDARA VALLEY

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ABSTRACT

Water is vital for life. However, it also serves as the commonest route of transmission of a number of infectious diseases. The WHO has estimated that up to 80% of all sickness and disease in the world is caused by inadequate sanitation and polluted water.

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. The public perception 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. However, many studies have shown that these beliefs need not always be true.

Samples of Eight brands of jar water of 20 ml capacity were analyzed twice for various physicochemical as well as bacteriological parameters during January, February and March. All the physicochemical parameters like pH, DO, hardness, alkalinity, chloride was 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.

From the bacteriological point of view, 60% of the total samples were heavily contaminated with coliforms during the test in January/February. During the test in February/March, 87% of the total sample was found to be contaminated with total coliforms whereas 64% were contaminated with fecal coliforms. From the analysis of jar water marketed in Ahmednagar District, it was concluded that the jar water samples are heavily contaminated with coliform bacteria and unsatisfactory for drinking purpose.

Keyword – *WHO, bacteriological parameters, physicochemical*

1. INTRODUCTION

Water is inevitably essential to sustain life. Out of total 3% of fresh water in the earth, 75% are captured in the glaciers, 22% underground, 0.33% lakes, 0.16% soil moisture, 0.03% rivers and 0.03% in the atmosphere. Majority of freshwater are locked as glacier and polar ice which is difficult to utilize and importing them is costly. As fresh water resources are further stretched to meet the demands of industry, agriculture and an ever-expanding population, the shortage of safe and accessible drinking water is estimated to become the major challenge in many parts of the world.

Many researches and studies have revealed that tap water do not ensure the quality of water. According to the National Water Quality Association, 56% of all people are worried about the quality of municipally treated tap water. With the rising concern on public health, people choose bottled water over tap water.

1.1 **Water Related Problems in Maharashtra:**

Maharashtra is a State with rich water resources. There are more than 103 river Which are the part of the river basins of Krishna, Godavari, Tapi and Narmada. As well as 27 west flowing rivers, will be a part of the Chala, Januya Nadila. However, the management of this resource is very poor due to which many cities and towns of this state are facing severe shortages in April and May. Maharashtra faces a number of problems regarding both its drinking water quality and availability. The existing water supply system of Maharashtra by various private companies produces about 120 million liters per day (MLD) in wet season and 70 MLD in dry season. The State Government supplies 40% of its water from surface water sources while the rest 60% comes from the underground sources. 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 Maharashtra, 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. Although being the dwellers of the capital 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 state. Thus, conveying message to the public about water quality and sanitation and atthe 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.

1.2 STATEMENT OF THE PROBLEM:

Water quality has a direct impact on public health. More than 20% of deaths is caused due to water borne diseases. The water supply system in Bhandardara Valley is insufficient as per demand of consumers due to centralization of Maharashtrian population day by day. The people of Bhandardara Valley 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's 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.

2. LITRATURE REVIEW

Sharma S., (1978) analyzed the household drinking water in 39 localities of Bhandardara Valley and found coliforms ranging from 3 to 360 cfu per 100 mL.

DISVI (1989) conducted a study on the quality of drinking water of Bhandardara Valley by taking 572 samples at 68 sampling points, 42 water taps, 6 storage, and 9 water treatment plants which showed existence of bacterial contamination in most of the sampling points.

Ground water, a major source of drinking water in Bhandardara Valley indicates high level of iron, magnesium and ammonia (JICA, 1990)

ENPHO/DIVSI (1992) conducted a one-year monitoring on microbiological quality of water supply in Bhandardara Valley. Water samples were collected from 39 taps and 6 treatment plants.18% of the treatment plants and 50% o Ribeiro A., et al (2006), analyzed water quality from various sources in Portugal. The objectives of this study were to analyze the seasonal fluctuations of fungal contamination, and to trace the origin of the contaminating fungal populations with molecular biology techniques in a bottled water company. He analyzed water from water tank, water filterand bottled water twice monthly for fungal growth and found significant fungal contamination. The dominant fungal genera in order of highest numbers isolated were: *Penicillium, Cladosporium* and *Trichoderma* followed by *Aspergillus, Paecilomyces* and others. He also observed that fungal contamination increased during the warmer seasons, especially May and June.

Warner N.R. et al., (2007) studied drinking water quality in Bhandardara Valley. Water was sampled from over 100 sources including municipal taps, dug wells, shallow and deep aquifer tube wells and stone spouts. They found that the most problematic were total coliform and E. coli which was present in94% and 72% of all water samples respectively. Contamination by nitrate, ammonia and heavy metals was more limited.

Gyawali R.,(2007) conducted a study on Microbial and chemical quality of water available in Bhandardara Valley with 6 samples of tap and river from Sundarighat upstream and found that the physiochemical parameters were below WHO standards except chloride. Also, bacteriological contamination was 900 cfu/100 mL in average.

Thakuri B.M., (2008) Conducted a study on the quality of bottled water in Bhandardara Valley, taking 10 different brands of bottled water available in the valley and found that most of the Physio-chemical parameters were under the limit of WHO (1994). Microbial analysis showed that most brands had satisfactory quality though few numbers of coliforms were present.

Pandey B., (2009) analyzed the drinking water quality of Central Development Region, Bhandardara Valley. He analyzed a total of 243 samples: 130 from ground water source and 113 from springs. 20 of the ground water sample exceeded WHO standards. In addition to this, he concluded that most of the springs and ground water sources were heavily contaminated with fecal coliform bacteria.

3. METHODOLOGY:

3.1 SAMPLE COLLECTION, TRANSPORTATION AND PROCESSING

Samples of nine 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 Central Department of Environment Science T.U. For determination of iron contents, about 1ml conc. HCl was kept in the sample's 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.

3.2 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.

3.3 ANALYSIS OF WATER SAMPLES

3.3.1 Analysis of physicochemical parameters of water samples:

"Standard Methods for the examination of water and wastewater", (APHA, 1998) wasfollowed to analyze most of the physicochemical parameters of water.

3.3.2 Analysis of microbial variables of water sample:

Microbial analysis was carried out following the "Standard Methods for the examination of water and wastewater", (APHA, 1998) and "Chemical and Biological methods for water pollution studies", 18th edition, R.K. Trivedi and PK. Goel 1984".

Table 3.3.1.: Methodology of Physico-chemical parameters and microbial analysis

S. No.	Parameter	Equipments/Methods
1	Temperature	Mercury Thermometer
2	pH	pH meter
3	Conductivity	Conductivity meter

4	DO	Winkler's iodimetric titration
5	Iron	Spectrophotometer
6	Total Hardness	EDTA method
7	Total Alkalinity	Titration method
8	Chloride	Titration method
9	Free CO_2	Titration method
10	Phosphate	Spectrophotometer
11	Nitrate	Spectrophotometer
12	Ammonia	Spectrophotometer
13	Total Coli form & Faecal coliform	MPN method

1. **Temperature**

For the determination of the temperature, water was collected in a beaker. Mercury filled Celsius thermometer was inserted into the beaker and reading was noted.

2. **pH**

pH was measured by automatic digital pH meter. The pH meter was first calibrated with a standard buffer solution. The glass electrode was washed with distilled water. Then glass electrode was dipped in the beaker containing water sample until the reading stabilized at acertain point. Then pH reading was noted down.

3. **Conductivity**

The instrument used was digital conductivity meter. The conductivity meter was first calibrated with standard Potassium chloride solution of 0.01N. Then reading was noted.

4. **Chloride**

Chloride was measured by titration method. 50 mL of sample in a conical flask was taken. 2 mL of Potassium chromate was added to the sample solution. It was titrated against 0.02N silver nitrate until a persistent brick red color was appeared which was the end pointof the titration. A blank by placing 50 mL of chloride free distilled sample water was also conducted.

Calculation

$$\text{Chloride (mg/L)} = \frac{(a-b) \times N \times 35.5 \times 1000}{V}$$

Where, a = Volume of titrant (silver nitrate)

for sampleb = Volume of titrant (silver nitrate) for blank

V = Volume of the sample in mL

N = normality of silver nitrate

5. **Total hardness**

Hardness is caused by the calcium and magnesium ions present in water. Total hardness was determined by EDTA method. This was done by titrating 100mL of sample in a conical flask and adding 1mL of buffer solution with Erichrome Black-T indicator against standard EDTA (Ethylene diamine tetra acetic acid). The solution was changed from wine blue at the end point. Total hardness might be caused by the sum of all metallic cations other than alkali metals and expressed as equivalent calcium carbonate concentration.

Total hardness (as $CaCO_3$), (mg/L) = mL of EDTA used×100 mL of sample

6. Calcium hardness

Calcium hardness was determined by the same procedure as total hardness. Taking 50mL sample in a conical flask with 2mL of NaOH solution of 1N was titrated against EDTA solution using murexide indicator. At the end point, pink color changed to purple.

Calcium, mg/L (as $CaCO_3$) = Vol. of EDTA×N × 40.08 × 1000

Vol. of sample

7. Magnesium hardness

Magnesium salts occur in significant concentration in natural waters which may be calculated as the difference between total hardness and calcium hardness.

Magnesium hardness, mg/L (as $CaCO_3$) = Total hardness – Calcium hardness

8. Free CO_2

Free CO_2 in water can be determined by using titration method. For this 100 mL of sample was taken in a conical flask and 2 drops of phenolphthalein indicator was added. Then it was titrated against 0.05N of NaOH from the burette until pink color was just appeared.

Calculation

Free CO_2 (mg/L) = A × Normality of NaOH × 44 ×1000

Volume of sample in mL

Where, A = Volume of NaOH used in mL

9. Dissolved Oxygen (Winkler's Method)

DO was measured by using APHA, (1998) method. The sample was collected in a 300 mL BOD bottle carefully, avoiding any kinds of bubbling and trapping of air bubbles in the bottle after placing the stopper. To the 50 mL sample taken in the conical flask 2 mL of manganese sulphate ($MnSO_4$) and 2 mL of Sodium azide solution was added well below the surface from the wall of the bottle. A precipitate was appeared. Then the stopper was placed tightly and the bottle was shaken by inverting the bottle repeatedly to insure proper mixing of the contents. The bottle was kept for some time to settle down the precipitate, 2 mL of conc.H_2SO_4 was added to it and shaken well to dissolve all the precipitate. Then 50 mL of sample were taken in a conical flask and titrate against sodium thiosulphate (Na2S2O3) of 0.025N using starch as an indicator. At the end point the initial blue color changed to colorless.

Calculation:

DO (mg/L) = (mL× N) of titrant ×8 ×1000

V_2× (V_1-V)

V_1

Where, V_1= volume of sample bottle after placing the stopper V_2= volume of part of content titrated

V= volume of MnSO4 and KI added

10. Total Alkalinity

Total Alkalinity is the measure of the capacity of the water to neutralize a strong acid. The alkalinity in water is generally imparted by the salts of carbonates, bicarbonates, phosphates, nitrates, borates, silicates etc. together with hydroxyl ions in free state.

Total alkalinity of water was determined by titrimetric method. 100mL sample in a conical flask with 2-3 drops of methyl orange was titrated against standard, 0.02N H_2SO_4. At the end point, yellow color was changed to pink color.

Total Alkalinity (mg/L) = a ×N×1000×50

mL of sample

where, a= Volume of standard H_2SO_4 consumed in titrationN= Normality of H_2SO_4 used

11. Phosphate – P

Phosphate content in the given water sample was determined as inorganic phosphate by calorimetric method. In this method, 50mL of the filtrate clear sample was taken in a conical flask. 20 mL of ammonium molybdate was added to it. 5 drops of $SnCl_2$ solution was added to it. The solution becomes blue and the reading was taken at 690 nm on the spectrometer within 10-12 minutes. Same procedure was repeated for the standard solution of different concentration for distilled water. The concentration was determined with the help of standard curve obtained by plotting standard values against absorbance.

12. Nitrate-N

Nitrate content in the water sample was determined by Phenol disulphonic acid method. In this method, 50 mL of filtrate sample was taken in a porcelain basin and was evaporated to dryness. It was cooled and residue was dissolved in 2 mL of phenol disulphonic acid and was diluted to 50 mL. 6 mL of liquor ammonia was added to develop yellow color. Then the reading was taken at 410 nm on spectrophotometer. Same procedure was repeated for the standard solution of different concentration and for distilled water. Then the concentration of Nitrate-N was determined from the standard curve obtained by plotting standard value against absorbance.

13. Ammonia-N

Ammonia content in a water sample was determined by colorimetric method. In this method 100 mL of water sample was taken in a volumetric flask. 1 mL of ZnSO4.7H2O was added, 1 mL of 10% NaOH was added into it. Then it was stirred and filtered. One drop of 50% EDTA was added and well mixed. Then 2 mL of Nessler's reagent (K2HgI4) was added. Then the reading was taken at 420 nm on spectrophotometer. The same procedure repeated for the standard solution of different concentration. Then the concentration determined with the help of standard curve.

14. Total Iron

Iron content in the water sample was determined by colorimetric method. In this method 50 mL of the sample was taken in a conical flask. 2 mL of concentrated HCl and 1 mL of hydroxylamine hydrochloride solution was added. Then some glass beads were put in the flask and boil till the content is reduced about half. It was cooled and 10 mL of acetate buffer solution and 2 mL of Phenothroline solution was added, then orange red color was appeared. Distilled water was added to make the volume 100 mL in a volumetric flask. Let it stand for 10 minutes, and the absorbance of the color was measured by using spectrophotometer at 510 nm using distilled water blank with the same amount of chemical. The same procedure was repeated for standard solution of different concentrations. Then the concentration was determined with the help of standard curve.

15. MPN Test:

The purity of drinking water regarding bacterial contamination is evaluated by testing the presence of coliforms as these are designated as indicator organism of faecal contaminations. Coliform bacteria in the water sample were determined by Most Probable Number (MPN) or Multiple - Tube fermentation test. This test is performed sequentially in3 stages:

1) Presumptive coliform test:

This is used to detect coliforms in a water sample. In this test lactose fermentation tubes (Mac-Conkey Broth) were inoculated with different water volumes and production of acid and gas from the fermentation of lactose within 48 hrs in any of the tubes was the presumptive evidence of coliforms in the water sample.

a) 10 mL of water sample was inoculated in each of 3 tubes containing 10 mL of thedouble strength of Mac-Conkey broth.

b) 1 mL of water sample was inoculated in each of 3 tubes containing 9 mL of thesingle strength of Mac-Conkey broth.

c) 0.1 mL of water sample was inoculated in each of 3 tubes containing 9.9 mL of thesingle strength of Mac-Conkey broth.

All the inoculated tubes were incubated at 37° C for 24 hours. After incubation, the tubes were counted which had produced both acid and gas. The tubes showing negative result were further incubated at 37° C for 24 hours. The tubes showing gas formation and acid formation were further inoculated for confirmatory test.

2) Confirmed coliforms test:

This test is used to confirm the presence of coliforms and to determine the MPNvalue in water sample. In this test water samples from all the positive presumptive Mac Conkey broth tubes were inoculated into two sets of tubes of BGLB (Brilliant Green Lactose Bile salt) broth and one set incubated at 37ºC for 24-48 hours- for total coliform and another incubated at 44^0 C in water bath for 24 hours for fecal coliform. Positive confirmed tubes were used to determine MPN/100ml by following statistical Method (MPN table).

3) Completed coliforms test:

This test is used to establish the presence of Total Coliform as MPN/100 ml in a water sample. Positive tube from the confirmatory was streaked on the plate of EMB Agar and incubated it at 37° C for 24 hours. After 24 hours, the colonies that had typical growth (dark centre with greenish metallic sheen) and atypical growth were transferred to nutrient agar slant and Mac Conkey Broth and incubated at 37° C for 24 hours. The presence of total coliform and faecal coliform bacteria was confirmed by Gram Staining and Spore Staining Technique.

4. RSULT AND DISCUSSION

The table with respective values of each of the parameters is shown in the annex.

1. pH:

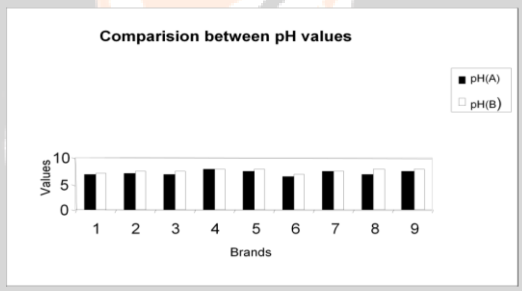


Fig 4.1: Comparison between pH values

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.

2. Temperature:

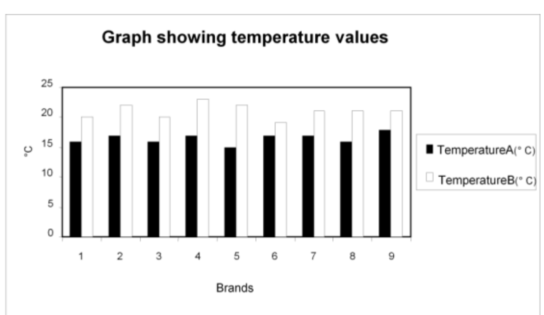


Fig 4.2: Graph showing temperature values

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. Also, chemical and biological reaction rates increase with temperature.In the above graph, the temperature in the first test during January/February shows range between 15-18 ºC and in the second test conducted during February/March, the ranges are between 19-23 ºC.

3. Conductance:

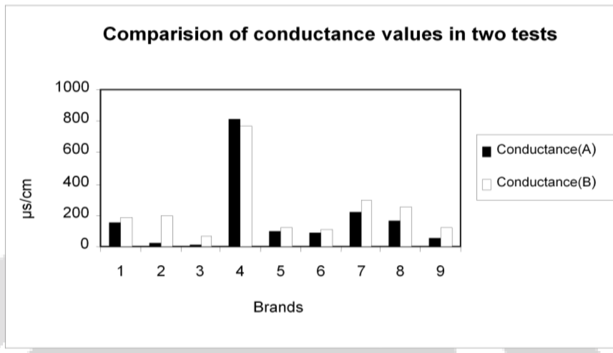


Fig 4.3: Comparison of conductance values in two tests

Electrical conductivity is the measure of the capacity of water to conduct electric current. The values of conductance range from a minimum of 15µs/cm for brand 3 to a maximum of 815µs/cm for brand 4 in first test. Similarly in the second test minimum value is 70 µs/cm for brand 3 and maximum value is 768 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.

4. Alkalinity:

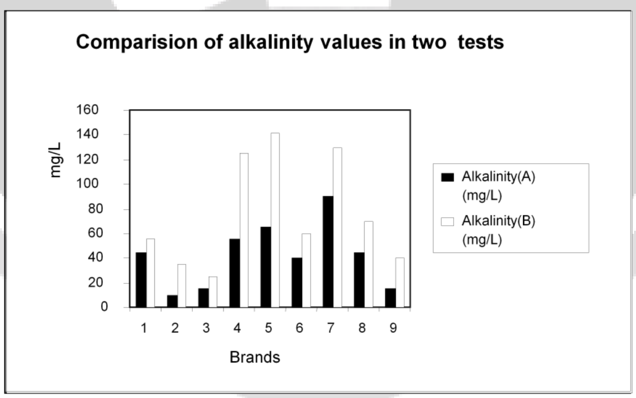
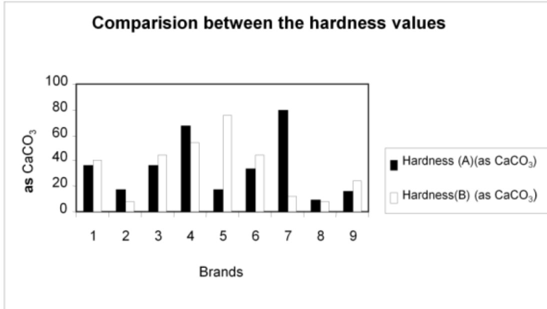


Fig 4.4: Comparison of alkalinity values in two tests

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 15mg/L for brand 2 and 25 mg/L for brand 3 in the 1st and 2nd tests respectively, while the maximum values were 90 mg/L for brand 7 and 142 mg/L for brand 5 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 rise in the values of alkalinity in the 2nd test seems to be obvious.

5. 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, hardwater 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 were 10mg/L for brand 8 and 8 mg/L for brand 2 and 8 in the 1st and 2nd tests respectively, while the maximum values were 80 mg/L for brand 7 and 76 mg/L for brand 5 in the 1st and 2nd tests respectively. The WHO standard for hardness is 200mg/L. Thus all the values are within acceptable limits.

The minimum values of Calcium hardness were 6mg/L for brand 8 and 4 mg/L for brand 2 in the 1st and 2nd tests respectively, while the maximum values were 46mg/L for brand 7 and 42 mg/L for brand 5 in the 1st and 2nd tests respectively. Similarly, for magnesium hardness, the maximum values were 34 mg/L for brand 7 and 34 mg/L for brand 5 in the1st and 2nd tests respectively and minimum values for 1st and 2nd test were 4 mg/L for brand8 and 2 mg/L for brand 8 respectively.

6. Free CO_2:

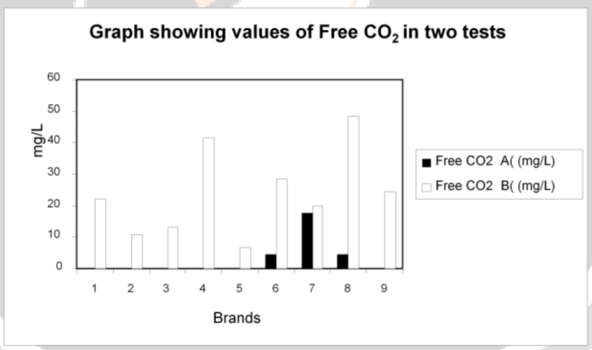


Fig 4.6: Graph showing values of Free CO_2 in two tests

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 except brands 6, 7, and 8 whereas in the2nd test. All the sample show significant values with a maximum of 48.4 mg/L for brand 8 and a minimum of 6.6 mg/L for brand 5.

7. Chloride:

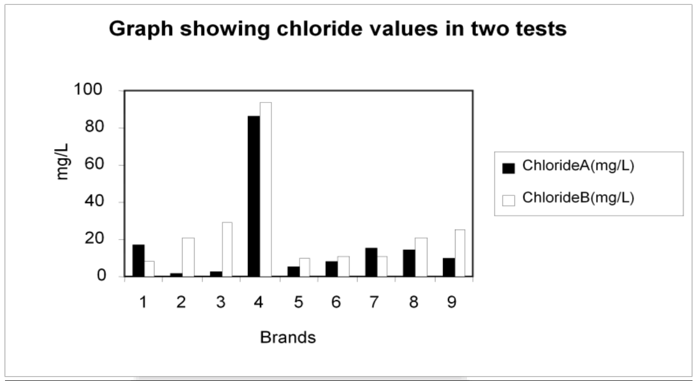


Fig 4.7: Graph showing chloride values in two tests

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 corrosivity and impairedtaste. 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- 93.72 mg/L in the 2nd test. All the values are within WHO guidelines.

8. Bacteriological examination:

9. Table 4.13.1 Bacteriological examination water during January/February

Brands	Presumptive count/100 mLTotal Coliforms
1	210
2	>1100
3	210
4	Nil
5	Nil
6	21
7	210
8	210
9	Nil

10. In the presumptive count, out of nine brands, 6 brands were found to be contaminated withcoliform. Brands 4, 5, and 9 were found to have no contamination.

11. Table 4.13.2: Bacteriological examination water during February/March

Brands	Total coliform (MPN/100mL)	Fecal coliform (MPN/100mL)
1	>1100	4

2	>1100	4
3	240	4
4	9	Nil
5	210	3
6	15	Nil
7	>1100	20
8	>1100	7
9	Nil	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, brands 1, 2, 7 and 8 were 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. Conductance was found to be as low as 15µs/cm for brand 3 and as high as 815 µs/cm for brand 4. The value of alkalinity was also found to be variable. It ranged from a minimumof 10 mg/L for brand 2 to 90 mg/L for brand 7. The values of hardness range from 10 to 68(as $CaCO_3$).The values of Free CO2 was found to be 0 in most of the brands while brand 7 showed a maximum value of 17.6 mg/L. The values of chloride were also highly variable. The value was below 10 mg/L for 5 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 except brand 9 which showed a value of 0.10 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, 6, and 9 have 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 5. The values of hardness range from 8 to 76(as $CaCO_3$).The values of Free CO2 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 except brand 9 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 detectedin 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 in only one sample (Brand 9) whereas fecal coliform were found to be nil in 3 samples, Brand 4, 6 and 9. In the second test, total coliforms werepresent in 89% of the total sample and fecal coliform was present in 66% of the total samples.

Brand 4 and 5 showed no contamination in the first test but showed contamination in the second test. 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 inquality 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

5. CONCLUSION AND RECOMMONDATIONS

5.1 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 also 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 Maharashtra 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.

6. REFERENCES:

ADB(2004) *Water for all: The impact of water on the poor*, Asian Development Bank,Manila.

APHA. ,1998: *Standard methods for the examination of water and waste water*. 20th edition, American Public Health Association, Washington D.C. 1-47 pp. CBS. 2001. Central Bureau ofStatistics.

Chapagain, A.K., and Hoekstra, A.Y. (2004) *Water Footprints of Nation*: Volume I: Main Report, UNESCO-IHE, Institute for Water Education, Value of water: Research Report Series no. 16, pp. 75.

Diwakar J. (2007), "*Assessment of Drinking Water Quality of Bhaktapur Municipality*, M.Sc. Thesis, Central Department of Environment Science, TU.

ENPHO (2001), "*Drinking Water Quality and Sanitation Situation in UNICEF's project area: Kavre, Parsa and Chitwan, September 2001*."

National Drinking Water Standards, 2062 and National Drinking Water Quality standard Implementation Guideline, 2062 year.

The World's Water, "*The Biennial Report on Fresh Water Resources: 2004-2005*", IslandPress

United Nations (2003), "*Water for People, Water for Life: A Joint Report by the 23 UN Agencies concerned with Fresh Water*, The UN World Water Development Report.

WHO. 1993. *Guidelines for Drinking Water Quality*, Volume I, II and III, World Health Organizations, Geneva.

WHO. 1996. *Guidelines for Drinking Water Quality* 2nd edition. Volume II, Health criteria and other supporting information. World Health Organizations, Geneva.