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Assessment of Physicochemical and Biological Properties and effect of temperature on bottled water of Different Brands in Lahore City

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Abstract

Drinking water quality is declining frequently. The poor quality of drinking water has enforced to purchase bottled water. Many mineral water companies were found selling low quality water. Hence, main purpose of research was to perform a comparative analysis of Multinational, National and local bottled water companies. Samples were collected from different regions of Lahore and evaluated on basis of their physicochemical, Mineral and Biological properties. Physicochemical analysis showed that only one sample of Brand A, B (multinational) did not justify the results against the nutritional label. Sodium, magnesium and sulphate of one sample did not justify the results against the nutritional. Arsenic metal was detected in sample number 1 (Result 0.01 ppm) but did not exceed the Maximum Admissible Limit by PFA/PSQCA and WHO. Biological Analysis showed results of brands A, B, C, D, E and J were negative for pathogenic microbes. TPC was zero for brands B & D while brands A, C, E and J were reported with minor growth. Brands F, G, H and I reported with positive results for pathogenic microbes and also carry the huge CFU count for the TPC and Yeast in it. Brand F results was positive for Coliforms, E.coli and Pseudomonas. So, all the tested bottled water brands are fit to drink.

Keywords: Local bottled water brands; Comparative study; Effect of temperature.

Introduction

Water is of major constituent of every living body, account for 55% to 75% by human body weight. Water maintains the cell's integrity and essential component that processes all metabolic reactions. Potable water also known as drinking water is the quality water used for drinking purpose and preparing food items but there are some specifications for consuming potable water. Globally, there are inadequate fresh water resources and majority of them are located far away from populated areas. The fairly predicted amount of consumable fresh water is 4×106 km^3 which is merely 0.2% of total amount of water found on earth. According to one's estimation, 2.5 billion individuals have face water scarcity (having <1000m^3 of renewable water/capita/year) by 2025. Per day intake of water is uncertain for various scientists. Its amount varies from person to person depending upon body size, age, gender, environmental conditions, daily activities and health and meal plan. Water is an irreplaceable asset and only liquid nutrient necessary for life and homeostasis and on an average sedentary adult should intake between 2-3 l of water daily. Minimum 8 glasses/day (240 mL/glass) of water intake is recommended by British Dietetic Association while 3.7 Liters/day & 2.7 Liters/day, for men and women respectively are suggested by US regulations [1-5].

By and large, there is lack of awareness among consumers regarding the proper functioning and role of mineral contents of water in our body. Calcium (Ca), Magnesium (Mg) and Sodium (Na) are significant components of water to our body that even having Ca and Mg rich meal cannot satisfy the need of these essential minerals, chances are there to be abundant in drinking water. Calcium contributes to fetal growth, pregnancy phase, lactation period, bones formation and teeth strengthening. Magnesium act as a co-factor in many metabolic processes happening in body. On the other side, consumption of Sodium (Na+) in high concentration can cause hypertension issue. Chloride ions (Cl-) increase the internal peristalsis movement of gut. Fluoride ions (F-) are beneficial for the bones protection and stronger teeth formation. Nitrates are important nitrogen source for nucleic acid production while nitrates present in excess can convert into nitrites leads to toxicity in human body.

In a study it is found that 60% infant mortality is associated with water and sanitation hygiene related infectious diseases. Diarrheal disorders due to intake of unsafe drinking water and poor hygiene and sanitary conditions lead to 1 billion of morbidity per year and 2.2 million of mortality per year in severe situations. In Pakistan, only 20% of total population people has access to safe and hygienic drinking water and remaining 80% individuals are enforced to consume contaminated water in their daily routine. Tap water of major localities of Lahore city has been found contaminated with fecal coliform colonies ranges from 1.30 x102 to 2.75 x105 CFU/ ml and not potable. This is the fact; water borne illness is a major vulnerable problem in Pakistan, major cause of increase in malnutrition rate and annual death rate. In Hyderabad, 500 people were recorded

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with gastrointestinal ailment and 3 deaths occurred. In Karachi (Essa Nagri) more than 200 people were infected with diarrheal disorders while death of 9 people was reported. Water ailments likewise influence the national economy, causes the obvious loss of 25-58 Billion yearly. The debilitated people due to waterborne illnesses utilize 20-40% beds of various clinics [6-12].

Bottled water consumption has been increased exponentially, globally and locally and increasing by ten percent every year worldwide. In the past five years, consumer spending per capita has increased at a rate of 10.8%, which has influenced the expenditure on bottled water in Pakistan. Though the bottled water has better taste than tap water, convenient to carry, found in every shop and fulfill dire thirst need when outside from home especially in summer. In case of elevated concentrations of fluoride, uranium or arsenic, most bottled waters are better alternatives when treatment of the well water is not practicable. It is reported in escalations of temperature causes the decreases of compression strength of bottled water especially in thin plastic bottles, this change is more obvious. Usually plastic bottles consist of Bi-phenol A and more often due to high environmental temperature exposure this chemical is leached into water ultimately affects the human body.

In Pakistan, however, sewage lines and consumption water sanitation system tracked corresponding to each other underground which causes outflows and fusing eventually result in decline of water quality people do not believe in quality of tap water and mostly are enforced to drink bottled water during travelling, in offices or even at households. Arsenic and bacteriological load are major issues in the water of Punjab cities. During last five years, there is a considerable increase in demand and consumption of bottled water in Pakistan due to awareness, drinking water contamination and safety perception of bottled water. Besides the increasing popularity of bottled water there are some challenges related to bottled water analysis including low level and complex composition of compounds in samples, composition changes in transport and storage due to reactions and dissolution from packaging material. Lahore is the second biggest city of Pakistan concerning population comprised of 10 million people. The temperature of Lahore city may exceeds from 45° C and it is quite often that bottled water expose to high temperature. Drinking bottled water has become famous in the community for quenching thirst and as a dietary (mineral) supplement as compared to tap water. Therefore, I am encouraged to analyze the quality of bottled water of different available company brands and influence of temperature on bottled water properties because as per best of my knowledge no research is conducted on investigating the quality and storage standards of bottled water selling according to their label and legislations in the Lahore city of Pakistan.

The quality water that is use to drink and use to cook food is known as potable water but what are the requirements for this potable water? Can either we consume the tap water as potable water or should we use bottled water? Actually to answer these questions different authorities and organizations has been established who developed standards for potable water while considering the body mineral requirements and health issues.

Water is the "Universal Solvent" and can dissolve much quantity of minerals in its original condition. It may rather dissolve minerals in such higher concentration that can lead to serious physiological or mental disorders which can cause the increase in death rate. To tackle this situation standards are developed by regulatory bodies at national and international level to make water safe for consumption. These regulatory bodies set the Maximum Admissible Concentration (MAC) of mineral constituents, physical particulars and microbes in potable water to keep consumer safe from any kind of hazard [13-17].

Generally, consumer is unaware about the functions of mineral constituents of water in our body. In water Calcium (Ca) and Magnesium (Mg) are so important to our body that even Ca and Mg rich meal cannot fulfill the need of these elements. Calcium play role for fetal growth, pregnancy, lactation, bones protection and teeth strengthening. Magnesium is important for many metabolic processes and serves as a co-factor. On the other hand, higher intake of Sodium (Na^+) can lead to hypertension. Chloride ions (Cl^-) enhance the internal peristalsis. Fluoride ions (F^-) are responsible for the strengthening of teeth and bones. Nitrates are the source of nitrogen for nucleic acid while excessive nitrates can turn into nitrites which are toxic to human body.

The daily water intake is ambiguous for scientists and researchers. It may vary from person to person because it depends on age, sex, physical activities, weather situation, meal plan and body mass. At least daily 8 glasses (240mL/glass) of water intake is proposed by British Dietetic Association while 3.7 Liters for men& 2.7 Liters for women per day is proposed by US Regulations which are greater than 18 years of age including of drinking water and beverages. However, it may vary due to physical activities and environmental conditions.

In whole world, fresh water resources are very limited while most of them positioned far away from human population. The quite amount of useable fresh water is approximately 4×106 km^3 that is only 0.2% of whole water present on earth. It is predicted that 3billions people will be in the water scarcity category having <1000 m^3 of renewable water per capita per year by 2025.

Water play vital role in the health of a living body. Owing to the bad cleaning practices and immoral activities of human beings, it is hugely infected with salts, oxides and ions of metals like calcium, lead, copper; microbes including Vibrio cholera. Consumption of this infected and bad quality of water is terrible for human health and can increase the mortality rate. Owing to the consumption of contaminated water, about 5 million peoples lead to death almost per annum. A wide amount of death is due to cholera which causes severe diarrhea. A survey of WHO estimates that almost 1.4million children could be saved by the consumption of safe and good quality water.

Concentration of salts in water also has a very important relationship with contamination of water. Higher the concentration of salts in water lesser will be the chance of growth of microorganisms in water because water availability will be less for the growth of microbes hence shelf life will be more. Although the innovation in research and development in

treatment of water, different kinds of techniques and technologies have been invented to reduce the unwanted attributes of water and to suppress the microbial contamination. These techniques and technologies include UV radiations equipment, water treatment technologies: Coagulation, sand bed filtration, reverse osmosis, chlorination, activated carbon filters, polishers, solar radiations and ozonation [18,19].

For a healthy life treated and pure water is a necessity. In Pakistan, 44% peoples are unable to acquire treated and hygienically safe water. In rural regions about 90% public is compelled to consume infected water. Due to this poor quality of water, 200,000 children are suffered from Diarrheal disorders and may also lead to death every year. Thus, water borne illness is a major issue in Pakistan, due to this reason death rate increases every year. Rate of malnutrition increased due to the multiple incidents of diarrhea which cause the increased incidents of death in people. For this reason, the year 2005 was catastrophic. A huge amount of waterborne illness incidents were reported in Hyderabad and Karachi. 500 peoples were infected by gastrointestinal disorders and 3 of them led to death in Hyderabad. In a colony of Karachi (Essa Nagri) more than 200 people were affected while 9 people died and 3 children were exaggerated.

Water related diseases also affect the national economy, almost a loss of 25-58 Billion annually. 20-40% hospital beds are occupied by the sick people due to waterborne illnesses. Population of the Lahore is 10 million while with respect to population Lahore is the second largest city of Pakistan. Due to this reason, safe and pure water supply is very difficult to all over areas of Lahore city. However, government of the Punjab has installed water filtration plants in different regions to meet the need of safe and clean water of public but due to poor cleaning and sanitation conditions people does not believe in quality of that filtered water as safe and they are desired to drink bottled water during travel, on job or even at home. So, therefore I am encouraged to analyze the quality of bottled water because as per best of my knowledge no research is conducted on the quality of bottled water selling in the Lahore city of Pakistan [20-22].

Materials and Methods

Materials and methods used for the assessment of physicochemical properties of different brands bottled water of all the tests regarding my research work were performed in water treatment and microbiology laboratory of Lotte Akhtar Beverages (Pvt.) Limited, PepsiCo Bottlers, Lahore. All the equipment and glassware used were calibrated before testing. They were also externally calibrated from Direct Line Engineering Corporation. All the chemicals used were purchased from continental traders Akbari road, New Anarkali, Lahore.

Area of study

Chemical & microbiological parameters of bottled water were checked while samples were collected from different regions of Lahore city.

Total 10 local, national& multinational brands of bottled water were picked as samples.

Sample collection

All the samples SKU that picked were 1500mL PET bottles. Samples were collected from three different regions of Lahore City. All samples were seal packed. No leakage was observed. Not a single sample has passed its Best Before date. All the collected samples were stored in refrigerator (8°C-10°C) until the testing performed. Water quality was evaluated by performing following analytical & microbiological tests. Every brand is evaluated in triplicate& samples were picked from three different regions of Lahore City

Physicochemical analysis

pH

HACH (HQ40d multi) was used to determine the pH of water samples under the procedures of Analytical Quality Manual HACH Instruments. Take at least 250 ml sample water in a well rinsed glass graduated beaker. Dip pH sensor in the sample after rinsing it with distilled water. Press the START button. Keep on dipping the sensor until reading get stable. However sensor should not touch glass body. Note the reading. Remove sensor from beaker, wash it with distilled water clean with tissue paper and dip it in 3 molar KCl solutions [23-25].

Total Dissolved Solids (TDS)

TDS of all the water samples was determined by using TDS mode of (thermo scientific orion star A212) Conductivity Meter at 23°C-25°C under the procedures of Analytical Quality Manual of Thermo Scientific. Sample was taken into the Beaker and adjusted the temperature of the sample at 25°C. TDS meter probe is rinsed with sample water and dip in the sample water. After stabilizing the value, reading was recorded in ppm.

Conductivity

Conductivity was measured by conductivity meter (thermo scientific orion star A212) at 23-25°C. The electrode of conductivity meter was flushed with a portion of sample water. Electrode dip into the sample water and measure button is pressed. Reading was recorded in µS/cm after it got stabilized.

Salinity

Salinity was measured by putting on the salinity measuring mode of conductivity meter (thermo scientific orion star A212) at 23°C-25°C. The electrode of meter was rinsed with sample water. Electrode dip into the sample water and measure button is pressed. Reading was recorded in PSU (Practical Salinity Unit) after it got stabilized.

Turbidity

HACH Colorimeter (DR/890) was used to find the turbidity of the water sample. Press PRGM and display will ask to add program number. Entered 95 by using keyboard, display will

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show. Take 10 ml Distilled water into a sample cell as a blank sample. Put this blank sample into cell holder and cover the sample cell with instrument cap. Press zero and display will show. Now take 10 ml sample in which turbidity is to be determined. Put this sample into cell holder and cover the sample cell with instrument cap. Press read result will be determined in NTU.

Total hardness

Titration method was used to find the total hardness of the water sample. Take 100 ml of sample in which hardness is to be determined. Put 3-4 drops of ammonia buffer solution in the sample to maintain a pH of 10. Put 1-2 drops of EBT (Eriochrome Black T) indicator. This will induce pink color to the sample. Titrate this sample with 0.01 M EDTA (Ethlyene Diamine Tetra Acetic Acid) solution. The end point of blue will be achieved. Stop titration at that point. Multiply the amount (Vol=mL) of EDTA used, by 10. Result will be the total hardness (ppm).

Total Hardness (ppm) = mL of EDTA x 10

Alkalinity

Indicator method of titration was used to find the total alkalinity of the water samples. Fill burette to zero line with 0.02 N sulfuric acid. Collect water sample in a 250 mL beaker. Rinse beaker several times with distilled water prior to collecting sample. Transfer water sample to 100-mL graduated cylinder. The bottom of the meniscus should be exactly on the 100-mL mark. Carefully transfer water sample from the cylinder to a clean, dry beaker. Add 2 drops of Methyl Purple Indicator it will give light purple color. Titrate slowly using 0.02N (N/50) H_2SO_4 till end point which is light pink color. Note the reading of H_2SO_4 (Vol=mL) used. Now calculate the Total Alkalinity in ppm by multiplying the volume used with 10.

Total Alkalinity (ppm) = mL of H2SO4 x 10

Mineral analysis:

Chloride

HANNA Chloride Kit (HI 3815) was used to measure the chloride found in water samples according to the procedure of Analytical Quality Manual of HANNA. Take 50 mL of water sample intended for chloride testing in a flask. Add 2 drops of Diphenyl Carbazone indicator in to sample. This will give red violet color to the sample. Add drops of nitric acid and shake until violet color turned into yellowish color. Take sample of Mercuric Nitrate solution in designated 1mL syringe and titrate with sample until color turned into violet. Note the final reading when its color turned into violet. Multiply the results with 100 to calculate chloride in ppm.

Fluoride

HANNA Fluoride Kit (HI 729) was used to measure the fluoride content of water samples under the procedure of analytical quality manual of HANNA.

Using the Fluoride testing kit follow the following procedure. Turn the meter on by pressing the button. All segments will be displayed. When the display shows Add with Press blinking, the meter is ready. Using supplied syringe add 2 mL of HI 7295 fluoride reagents to both cuvettes. Fill the first cuvette to the line with 8mL of de-ionized water and the second cuvette to the line with 8mL of sample water. Replace the cap and invert several times to mix. Place the first cuvette (de-ionized water) into the meter and close the lid. Press and hold the button until the timer is displayed on the LCD (the display will countdown prior to the measurement) or, alternatively, wait for 2 minutes and press the button. When the display shows Add C.2 (Cuvette 2) with Press blinking the meter is zeroed. Remove the 1st cuvette (de-ionized water) and insert the 2nd cuvette (sample water) into the instrument and press the button. The instrument directly displays the concentration of fluoride in ppm. The meter automatically turns off after 2 Minutes [26,27].

Sulphate

HACH Colorimeter (DR/890) was used to measure the sulphate of the water sample by selecting PRGM 91 on the colorimeter under the procedure of Analytical Quality Manual of HACH Instruments. Take HACH Meter to perform sulphate test. Press PRGM and display will ask to add program number. Enter 91 by using keyboard. Take 10 mL Distilled Water into a sample cell as a blank sample. Put this blank sample into cell holder and cover the sample cell with instrument cap. Press ZERO and display will show 0.000. Now take 10mL sample into the cell in which sulphate is to be determined. Add contents of one SulphaVer4 Reagent Powder Pillow in sample. Press timer and enter to calculate reaction time. Timer will take 5 minutes. Then replace blank sample from colorimeter with water sample. Press READ result will be displayed on screen in ppm.

Nitrate

HACH Colorimeter (DR/890) was used to measure the Nitrate of the water sample by selecting PRGM 55 on the colorimeter under the procedure of Analytical Quality Manual of HACH Instruments. Take HACH Meter to perform Nitrate test. Press PRGM and display will ask to add program number. Enter PRGM 55 by using keyboard. Take 10mL Distilled water into a sample cell as a blank sample. Put this blank sample into cell holder and cover the sample cell with instrument cap. Press ZERO and display will show 0.000. Now take 15mL sample into the cell in which Nitrate is to be determined. Add the contents of one NitraVer6 Nitrate Reagent Powder Pillow in sample. Press TIMER and ENTER to calculate reaction time. 1st timer is of 3 minutes. After passing first timer press ENTER for 2nd timer which is of 2 minutes. Now take 10mL from 15mL of above sample in which we have already added NitraVer6 and add one NitriVer3 Nitrite reagent Powder pillow. Press ENTER again to start 3rd timer which is of 15 minutes. Then replace blank sample from colorimeter holder with water sample. Press READ result will be displayed on screen in ppm.

Nitrite

HACH colorimeter (DR/890) was used to measure the Nitrite of the water sample by selecting PRGM 63 on the colorimeter under the procedure of Analytical Quality Manual of HACH Instruments. Take HACH meter to perform nitrite test. Press PRGM and display will ask to add program number. Enter PRGM

63 by using keyboard. Take 10mL Distilled water into a sample cell as a blank sample. Put this blank sample into cell holder and cover the sample cell with instrument cap. Press ZERO and display will show 0.000. Now take 5mL sample into cell in which Nitrite is to be determined. Add the contents of one NitriVer3 nitrite reagent powder pillow in sample. Press timer and enter to calculate reaction time which is of 20 minutes. Then replace blank sample from colorimeter holder with water sample. Press READ result will be displayed on screen in ppm.

Free Chlorine

HACH colorimeter (DR/890) was used to measure the Free Chlorine in water sample by selecting PRGM 10 on the colorimeter under the procedure of analytical quality manual of HACH Instruments. Take HACH Meter to perform chlorine test. Press PRGM and display will ask to add program number. Enter 10 by using keyboard. Take 10 ml Distilled water into a sample cell as a blank sample. Put this blank sample into cell holder and cover the sample cell with instrument cap. Press zero and display will show. Now take 10ml sample in which chlorine is to be determined. Add two tablets of DPD1 in the sample solution. In the presence of free chlorine sample will show a pink color. Put this sample into cell holder and cover the sample cell with instrument cap. Press read result will be displayed on screen in ppm.

Magnesium

HANNA HI96752 magnesium kit was used to find the concentration of magnesium of water samples in ppm. Procedure was followed according to the Instruction Manual HI96752 of HANNA. Turn the meter on by pressing ON/OFF. Select PRGM P2for magnesium through RANGE/GLP button. Using a 1 mL syringe, add exactly 1 mL of HI93752A-Mg buffer reagent A. Now use pipette to fill the cuvette up to the 10 mL mark with the HI93752B-Mg Indicator Reagent B. Place the cap and invert several time for mixing. Now place the cuvette in the Kit Holder and ensure the cap position settled down. Now press zero and note the value is zero. Now use other syringe and ADD 0.5 mL of the water sample in the cuvette. Do not use previous syringe used for Reagent A. Now place the cap and invert the cuvette several times. Now place the cuvette in Kit Holder and ensure cap position and wait for 15 seconds. Presses read and note the magnesium reading. Kit will display the reading in ppm on LCD.

Sodium

Thermo scientific orion dual star pH/ISE Meter was used to calculate the Sodium content of the water samples under the procedure given in Work Method Manual of Thermo Scientific. Using the Mineral Testing Meter follow the following procedure. Take 50mL of 1000ppm Na standard solution & add 5mL ISA (Ionic Strength Adjustor). It will be 1000ppm Na Standard Solution for calibration. Similarly take 45mL de-ionized water & add 5mL from 1000ppm Na standard solution & 5mL ISA. 100ppm Na Standard Solution is prepared. Press calibration button & dip all probes in 100ppm Na standard solution. Note the stabilized reading after measuring. ENTER 100 if meter show deviation from 100ppm. Click next button. Put all probes in 1000ppm Na standard solution. Measure the sample reading. Enter 1000 if meter show deviation from 1000 ppm. Click calibration done button. Note the slope reading. It should be 54-60. Rinse all probes with rinsing water which was prepared after adding ISA in De-ionized water.

Potassium

Thermo scientific orion dual star pH/ISE meter was used to calculate the Potassium content of the water samples under the procedure given in work method manual of thermo scientific. Using the mineral testing meter follow the following procedure. Take 25.6mL of 0.1M K standard solution & add 2 mL ISA & make it up to 100mL. It will be 1000ppm K Standard Solution for calibration. Take 2.56 mL of 0.1M K standard solution & add 2 mL ISA & make it up to 100 mL. It will be 100 ppm of Standard Solution for calibration. Press calibration button & dip all probes in 100 ppm K standard solution. Note the stabilized reading after measuring. Enter 100 if meter show deviation from 100ppm. Click next button. Put all probes in 1000 ppm K standard solution. Measure the sample reading. Enter 1000 if meter show deviation from 1000 ppm. Click calibration done button. Note the slope reading. It should be 54-60. Rinse all probes with rinsing water which was prepared after adding ISA in de-ionized water.

Arsenic

Macherey-Nagel Quantofix®Arsenic10 REF 91334 Kit was used to quick find of Arsenic level in water sample by following the Instruction Leaflet in Kit Box by MACHEREY-NAGEL.Using the Arsenic Testing Kit follow the following procedure.Use the sample syringe. Fill 3×10mL sample water into the reaction vessel. After adding each of following reagents, shake gently for about 2 seconds.1 drop of As-1 Liquid Reagent. 1 measuring spoon of As-2 powder reagent. 1 measuring spoon of As-3 Powder Reagent. Immediately afterward dip the test strip with the test field about 2 cm deep into the reaction vessel and then fit the lid. To vent the reaction vessel, pierce the lid with needle and leave the needle in the lid. Wait for 10 minutes. Afterward dip the test strip with the test field into distilled water for two seconds. Shake off excess liquid and compare with color scale. Color scale tells the concentration in ppm.

Microbiological analysis

Total Plate Count (TPC)

Incubation: Invert the standard method agar petri dish and incubate the plate at 37 ± 2°C for 48 ± 2 hours.

Colony Counting: After incubation, promptly count all colonies on the membrane surface. If it is not possible to count immediately after incubation, store plates at approximately 4°C for a period of not more than 24 hours. Avoid mistaking any media or sample particles, or precipitating matter that may be on the membrane surface for pinpoint colonies.

- If there are more than 200 colonies approximately on the plate, divide the plate into convenient radial sections (2, 4) and count all the colonies in one or more sections. Multiply the total in each case by the appropriate factor, to obtain an estimate of the total number of colonies for each sample.

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- If there are more than 300 colonies on the plate record the number as Too Numerous to Count (TNTC).
- Count growth in chains as 1 colony-forming unit.
- If the entire plate is covered with growth, i.e. no discrete colonies, record as Too Numerous To Count (TNTC).
- Results should be reported per volume filter for membrane filtration techniques (100 mL)

Yeast & mold

Incubation: Incubate Orange Serum Agar plates at 25±1°C for 120 hours (5 days) ± 2hrs.

Identification: Yeast will show yellow/white colonies while Mold will give cottonish like appearance on the plate.

Colony counting: After incubation, promptly count individual colonies on each plate. Differentiate between yeast, mold and bacteria by morphology. If further examination is required, prepare a wet mount of the colony and examine the cell structure under the microscope.

- If spreaders occur on the plate, count the other colonies on representative portions only when colonies are well distributed in spreader free areas and the area covered by spreaders does not exceed one half of the plate area. Count each spread colony as 1 Colony-Forming Unit (CFU).
- Count growth in chains as 1 Colony-Forming Unit (CFU).
- If the entire plate is covered with growth, i.e. no discrete colonies, record as Too Numerous to Count (TNTC).

E.coli & coliforms

Incubation: Invert the Petri dish and incubate the Brilliance E.coli & Coliforms Agar plate at 37 ± 1°C for 24 ± 2 hours.

Identification: E.Coli will give Purple color colonies and Coliforms will give pink color colonies.

Colony Counting: Count pink colonies for coliforms evaluation and purple colonies for E.coli on BEC agar, all other bacteria will form blue or colorless colonies.

Fecal streptococcus

Incubation: Invert the Petri dish and incubate the m-Enterococcus Agar plate at 37 ± 1°C for 48 ± 2 hours.

Identification: Fecal streptococcus will show dark red colonies on plate.

Colony Counting: After completion of incubation period, count the number of dark red colonies on each plate and record results.

Pseudomonas aeruginosa

Incubation: Invert the petri dish and incubate the pseudomonas cetrimide agar plate at 37 ± 1°C for 48 ± 2 hours.

Identification: Pseudomonas will form yellow colonies and Pseudomonas aeruginosa will form dark greenish colonies.

Colony counting: After completion of incubation period, count the number of colonies on each plate and record results.

Effect of temperature

All collected samples from different regions of Lahore were assessed in summers (June-July) and winters (October-November) to study the effect of temperature.

Results and Discussions

Brand A

Brand A is a well-known multinational brand. 3 samples of this brand were analyzed in both seasons (temperature variants). The results of sodium, potassium and magnesium were found almost same and satisfactory with respect to the specifications of PFA/PSQCA and WHO but only one sample did not justify the results against the nutritional label of the brand. Label shows the minimum of 7ppm sodium in water while the sample result was 6.38 ppm in sampleA-3. Whereas, the results of chloride, fluoride, nitrate, nitrite, sulphate and chlorine were parallel to the benchmark standards of PFA/PSQCA, WHO and also complied with the label specifications. Arsenic metal was not detected. Average pH and TDS was 7.51 and 217.17 ppm respectively and also found in specification ranges mentioned in table. Likewise average value of salinity was 0.268PSUbecause it depends on TDS of the water. Turbidity of water was Zero. Moreover, average total hardness was 133.67 ppm while WHO recommends less than 500 ppm.

Sr.No	Tests	Results				Specifications as per		
		A-1	A-2	A-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	Min (ppm)	(ppm)	(ppm)
1	Sodium (Na)	8.21	7.97	6.38	7.52	7	50	200
2	Potassium (K)	1.77	1.13	1.69	1.53	0.01	10	-
3	Magnesium (Mg)	18	13	15	15.33	5	50	-

4	Chloride	95	91	88	91.33	75	250	200-300
5	Fluoride	0.08	0.14	0.05	0.09	-	0.7	1.5
6	Nitrate	0.03	0.03	0.02	0.03	-	10	50
7	Nitrite	0.033	0.01	0.02	0.021	-	1	3
8	Sulphate	37	31	34	34	15	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	Ph	7.36	7.65	7.56	7.51	6.5-8.5	6.5-8.5	-
12	TDS	218.5	222.4	210.6	217.17	175-350	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	29	36	32	32.33	-	-	-
15	Salinity (PSU)	0.263	0.269	0.253	0.261	-	-	-
16	Total Hardness	140	127	137	133.67	-	-	500

Table 1(a): Analytical results of brand A in june-july.

Sr.No	**Tests**	**Results**				**Specifications as per**		
		A-1	**A-2**	**A-3**	**Average**	**Label**	**PFA/ PSQCA(MAC)**	**WHO**
		(ppm)	**(ppm)**	**(ppm)**	**(ppm)**	**Min (ppm)**	**(ppm)**	**(ppm)**
1	Sodium (Na)	8.21	7.97	6.38	7.52	7	50	200
2	Potassium (K)	1.78	1.13	1.68	1.53	0.01	10	-
3	Magnesium (Mg)	18	13	15	15.33	5	50	-
4	Chloride	95	91	88	91.33	75	250	200-300
5	Fluoride	0.08	0.14	0.05	0.09	-	0.7	1.5
6	Nitrate	0.03	0.02	0.03	0.03	-	10	50
7	Nitrite	0.033	0.01	0.02	0.021	-	1	3
8	Sulphate	37	31	34	34	15	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	Ph	7.36	7.61	7.55	7.51	6.5-8.5	6.5-8.5	-
12	TDS	218.7	222.4	210.6	217.17	175-350	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	29	36	32	32.33	-	-	-
15	Salinity (PSU)	0.264	0.268	0.253	0.261	-	-	-

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16	Total Hardness	140	127	134	133.67	-	-	500

Table 1(b): Analytical results of brand A in october-november.

Source	DF	SS	MS	F	P
Treatment	15	172930	11528.7	1542.21	0
Error	32	239	7.5		
Total	47	173170			

Table 1(c): Completely randomized AOV for results, grand mean 33.799, CV 8.09.

Brand B

Brand B is a multinational brand. 3 samples of different batch numbers of this brand were analyzed. The results of sodium, potassium and magnesium were found satisfactory with respect to the specifications of PFA/PSQCA and WHO but only one sample did not justify the results against the nutritional label of the brand. Label shows the sodium range from 2-20ppm in water while the sample result was 1.76 ppm in sample B-1. Whereas, the results of chloride, fluoride, nitrate, nitrite, sulphate and chlorine were parallel to the benchmark standards of PFA/PSQCA, WHO and also complied with the label specifications. Arsenic metal was not detected. Average pH and TDS was 7.44 and 155.77ppm respectively and also found in specification ranges mentioned in table. Likewise average value of salinity was 0.2PSU because it depends on TDS of the water. Turbidity of water was Zero. Moreover, average total hardness was 117.33 ppm while WHO recommends less than 500 ppm.

Sr.No	Tests	Results				Specifications as per		
		B-1	B-2	B-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	1.76	3.71	4.82	3.43	Feb-20	50	200
2	Potassium (K)	4.62	5.33	4.97	4.973	01-Oct	10	-
3	Magnesium (Mg)	23	25	26	24.67	15-30	50	-
4	Chloride	12	11	10	11	1-120	250	200-300
5	Fluoride	0.35	0.31	0.37	0.34	0.1-0.7	0.7	1.5
6	Nitrate	0.04	0.03	0.05	0.04	-	10	50
7	Nitrite	0	0	0	0	-	1	3
8	Sulphate	80	76	81	79	50-100	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.27	7.41	7.65	7.44	-	6.5-8.5	-
12	TDS	158.8	151.4	157.1	155.77	≤ 500	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	44	47	52	47.67	-	-	-

15	Salinity (PSU)	0.206	0.193	0.2	0.2	-	-	-
16	Total Hardness	112	119	121	117.33	-	-	500

Table 2(a): Analytical results of brand B in June-July.

Sr.No	Tests	Results				Specifications as per		
		B-1	B-2	B-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	1.76	3.71	4.82	3.43	Feb-20	50	200
2	Potassium (K)	4.62	5.33	4.97	4.973	01-Oct	10	-
3	Magnesium (Mg)	23	26	26	24.67	15-30	50	-
4	Chloride	12	11	10	11	1-120	250	200-300
5	Fluoride	0.35	0.32	0.38	0.34	0.1-0.7	0.7	1.5
6	Nitrate	0.04	0.03	0.05	0.06	-	10	50
7	Nitrite	0	0	0	0	-	1	3
8	Sulphate	80	76	81	79	50-100	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.27	7.41	7.65	7.44	-	6.5-8.5	-
12	TDS	158.9	151.4	157.1	155.77	≤ 500	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	44	47	52	47.69	-	-	-
15	Salinity (PSU)	0.206	0.193	0.2	0.2	-	-	-
16	Total Hardness	112	119	121	117.33	-	-	500

Table 2(b): Analytical results of brand B in October-November.

Source	DF	SS	MS	F	P
Treatment	15	103811	6920.74	1662.96	0
Error	32	133	4.16		
Total	47	103944			
Grand Mean	28.241	CV	7.22		

Table 2(c): Completely randomized AOV for results.

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Brand C

Brand C is our national brand of Pakistan having multiple national and international certifications. Total 3 samples of different batch numbers of this brand were analyzed. The results of sodium, potassium and magnesium were found satisfactory with respect to the specifications of PFA/PSQCA and WHO but only one sample did not justify the results against the nutritional label of the brand. Sodium, magnesium and sulphate of sample C-1 found out of specs with respect to the nutritional label of the brand.

Label shows the range from 10 ppm-30 ppm in water for sodium, magnesium and sulphate each while the sample result was 7.86 ppm, 9 ppm and 8 ppm for sodium, magnesium and sulphate respectively in sample C^{-1}. Whereas, the results of chloride, fluoride, nitrate, nitrite and chlorine were parallel to the benchmark standards of PFA/PSQCA, WHO and also complied with the label specifications. Arsenic metal was not detected. Average pH and TDS was 7.61 ppm and 235.73 ppm respectively and also found in specification ranges mentioned in table. Likewise average value of salinity was 0.277PSU because it depends on TDS of the water. Turbidity of water was zero. Moreover, average total hardness was 207.33 ppm while WHO recommends less than 500 ppm.

Sr.No	Tests	Results				Specifications As per		
		C-1	C-2	C-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	7.86	10.56	13.1	10.51	Oct-30	50	200
2	Potassium (K)	2.92	1.33	1.98	2.08	< 2	10	-
3	Magnesium (Mg)	9	12	13	11.33	Oct-30	50	-
4	Chloride	12	14	14	13.33	< 20	250	200-300
5	Fluoride	0.47	0.45	0.38	0.43	< 1	0.7	1.5
6	Nitrate	0.55	0.35	0.41	0.44	-	10	50
7	Nitrite	0.07	0.03	0.05	0.05	-	1	3
8	Sulphate	8	16	11	11.67	Oct-30	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.89	7.61	7.33	7.61	-	6.5-8.5	-
12	TDS	247.9	233.8	225.5	235.73	200-350	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	233	225	219	225.67	-	-	-
15	Salinity (PSU)	0.293	0.27	0.267	0.277	-	-	-
16	Total Hardness	197	211	214	207.33	< 250	-	500

Table 3(a): Analytical results of brand C in June-July.

Sr.No	Tests	Results				Specifications As per		
		C-1	C-2	C-3	Average	Label	PFA/ PSQCA(MAC)	WHO

		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	7.89	10.56	13.1	10.51	Oct-30	50	200
2	Potassium (K)	2.92	1.33	1.98	2.08	< 2	10	-
3	Magnesium (Mg)	9.3	12	13	11.33	Oct-30	50	-
4	Chloride	12	14	14	13.33	< 20	250	200-300
5	Fluoride	0.47	0.45	0.38	0.43	< 1	0.7	1.5
6	Nitrate	0.55	0.35	0.41	0.44	-	10	50
7	Nitrite	0.07	0.03	0.05	0.05	-	1	3
8	Sulphate	8	16	11	11.67	Oct-30	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.89	7.61	7.33	7.61	-	6.5-8.5	-
12	TDS	247.9	233.8	225.5	235.73	200-350	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	233	225	219	225.67	-	-	-
15	Salinity (PSU)	0.293	0.27	0.267	0.277	-	-	-
16	Total Hardness	197	211	214	207.33	< 250	-	500

Table 3(b): Analytical results of brand C in October-November.

Source	DF	SS	MS	F	P
Treatment	15	351343	23422.9	1294.5	0
Error	32	579	18.1		
Total	47	351922			
Grand Mean	45.404	CV	9.37		

Table 3(c): Completely randomized AOV for results.

Brand D

Brand D is our national certified brand of Pakistan and also export their wide variety of products to multiple countries in the world. Total 3 samples of different batch numbers of this brand were analyzed. The results of sodium, potassium, magnesium, chloride, fluoride, nitrate, nitrite, sulphate and chlorine were finely parallel to the benchmark standard's ranges of PFA/PSQCA, WHO and also complied with the label specifications. Arsenic metal was not detected. Average pH and TDS was 7.34 and 201.6ppm respectively and also found in specification ranges mentioned in table. Likewise average value of salinity was 0.247PSU because it depends on TDS of the water. Turbidity of water was Zero. Moreover, average total hardness was 121.67 ppm while WHO recommends less than 500 ppm.

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Sr.no	Tests	Results				Specifications As per		
		D-1	D-2	D-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	Approx. (ppm)	(ppm)	(ppm)
1	Sodium (Na)	6.72	7.36	7.99	7.36	May-30	50	200
2	Potassium (K)	1.62	2.11	1.93	1.89	0.01-4	10	-
3	Magnesium (Mg)	5	7	8	6.67	Mar-15	50	-
4	Chloride	82	85	86	84.35	60-110	250	200-300
5	Fluoride	0.23	0.31	0.26	0.27	0.1-0.6	0.7	1.5
6	Nitrate	0.03	0.01	0	0.01	-	10	50
7	Nitrite	0	0	0	0	-	1	3
8	Sulphate	41	35	41	38.67	Oct-50	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.62	7.34	7.07	7.37	6.5-8.5	6.5-8.5	-
12	TDS	198.7	206.4	199.7	201.6	150-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	30	24	19.5	24.33	-	-	-
15	Salinity (PSU)	0.244	0.252	0.246	0.247	-	-	-
16	Total Hardness	114	122	129	121.67	100-175	-	500

Table 4(a): Analytical results of brand D in June-July.

Sr.no	Tests	Results				Specifications As per		
		D-1	D-2	D-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	Approx. (ppm)	(ppm)	(ppm)
1	Sodium (Na)	6.72	7.36	7.99	7.36	May-30	50	200
2	Potassium (K)	1.62	2.11	1.93	1.89	0.01-4	10	-
3	Magnesium (Mg)	5	7	8	6.67	Mar-15	50	-
4	Chloride	82	84	86	84.33	60-110	250	200-300
5	Fluoride	0.23	0.31	0.26	0.27	0.1-0.6	0.7	1.5
6	Nitrate	0.03	0.01	0	0.01	-	10	50
7	Nitrite	0	0	0	0	-	1	3

8	Sulphate	40	35.1	41	38.67	Oct-50	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.62	7.34	7.07	7.34	6.5-8.5	6.5-8.5	-
12	TDS	198.7	206.4	199.8	201.6	150-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	30	24	19	24.33	-	-	-
15	Salinity (PSU)	0.244	0.252	0.246	0.247	-	-	-
16	Total Hardness	114	122	129	121.69	100-175	-	500

Table 4(b): Analytical results of brand D in October-November.

Source	DF	SS	MS	F	P
Treatment	15	148575	9905.02	1301.81	0
Error	32	243	7.61		
Total	47	148819			
Grand Mean	30.899	CV	8.93		

Table 4(c): Completely randomized AOV for results.

Brand E

Brand E is our national brand of Pakistan and also certified with PSQCA. Total 3 samples of different batch numbers of this brand were analyzed. The results of sodium, potassium, magnesium,chloride, fluoride, nitrate, nitrite, sulphate and chlorine were found consent with the specifications of PFA/ PSQCA and WHO but only one sample did not justify the results against the nutritional label of the brand. Label shows thesulphate range from 15-55ppm in water while the sample result was 14ppm in sample E-1 whereas Arsenic metal was not detected. Average pH and TDS was 7.33 and 208.17ppm respectively and also found in specification ranges mentioned in table. Likewise average value of salinity was 0.254PSU because it depends on TDS of the water. Turbidity of water was Zero. Moreover, average total hardness was 119 ppm while WHO recommends less than 500 ppm.

Sr.No	Tests	Results				Specifications As per		
		E-1	E-2	E-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	9.06	20.6	11.43	13.7	Jul-30	50	200
2	Potassium (K)	1.75	2.14	1.66	1.85	0.03-6	10	-
3	Magnesium (Mg)	5	7	8	6.67	May-18	50	-
4	Chloride	95	88	91	91.33	60-130	250	200-300
5	Fluoride	0.3	0.35	0.33	0.32	-	0.7	1.5
6	Nitrate	0.02	0.03	0.01	0.02	-	10	50

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7	Nitrite	0	0	0	0	-	1	3
8	Sulphate	14	16	15	15	15-55	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.11	7.65	7.22	7.33	6.5-8.5	6.5-8.5	-
12	TDS	198.4	208.9	217.2	208.18	130-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	35	41	38	38	-	-	-
15	Salinity (PSU)	0.243	0.256	0.268	0.254	-	-	-
16	Total Hardness	114	120	123	119	-	-	500

Table 5(a): Analytical results of brand E in June-July.

Sr.No	**Tests**	**Results**				**Specifications as per**		
		E-1	E-2	E-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	9.06	20.6	11.43	13.7	Jul-30	50	200
2	Potassium (K)	1.75	2.14	1.66	1.86	0.03-6	10	-
3	Magnesium (Mg)	5	7	8	6.67	May-18	50	-
4	Chloride	95	89	91	91.33	60-130	250	200-300
5	Fluoride	0.3	0.35	0.31	0.32	-	0.7	1.5
6	Nitrate	0.01	0.03	0.01	0.02	-	10	50
7	Nitrite	0	0	0	0	-	1	3
8	Sulphate	14	16	15	15	15-55	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.11	7.65	7.23	7.33	6.5-8.5	6.5-8.5	-
12	TDS	198.4	208.9	217.5	208.17	130-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	35	41	38	38	-	-	-
15	Salinity (PSU)	0.243	0.251	0.268	0.254	-	-	-
16	Total Hardness	115	120	123	119	-	-	500

Table 5(b): Analytical results of brand E October-November.

Source	DF	SS	MS	F	P
Treatment	15	156202	10413.5	970.25	0
Error	32	343	10.7		
Total	47	156546			
Grand Mean	31.352	CV	10.45		

Table 5(c): Completely randomized AOV for results.

Brand F

Brand F is the local brand of Lahore and produced in the area of Model Town. Total 3 samples of different batch numbers of this brand were analyzed. The results of sodium, potassium, magnesium, chloride, fluoride, nitrate, nitrite, sulphate and chlorine were finely parallel to the benchmark standard's ranges of PFA/PSQCA, WHO and also complied with the label specifications. Arsenic metal was not detected. Average pH and TDS was 7.49 and 245.2ppm respectively and also found in specification ranges mentioned in table. Likewise average value of salinity was 0.28PSU because it depends on TDS of the water. Turbidity of water was Zero. Moreover, average total hardness was 94 ppm while WHO recommends less than 500 ppm.

Sr.No	Tests	Results				Specifications As per		
		F-1	F-2	F-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	17.6	13.62	18.37	16.53	Jul-30	50	200
2	Potassium (K)	3.43	2.72	2.53	2.89	0.01-5	10	-
3	Magnesium (Mg)	7	5	9	7	Mar-15	50	-
4	Chloride	73	80	78	76.67	60-120	250	200-300
5	Fluoride	0.5	0.49	0.49	0.48	0.1-0.6	0.7	1.5
6	Nitrate	0.01	0.05	0.02	0.03	-	10	50
7	Nitrite	0.014	0	0.011	0.008	-	1	3
8	Sulphate	30	25	32	29	Oct-50	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.14	7.45	7.89	7.49	6.5-8.5	6.5-8.5	-
12	TDS	252.7	235.5	247.4	245.2	100-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	119	126	134	126.33	-	-	-
15	Salinity (PSU)	0.298	0.272	0.285	0.28	-	-	-
16	Total Hardness	95	84	103	94	-	-	500

Table 6 (a): Analytical results of brand F in June-July.

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Sr.No	Tests	Results				Specifications As per		
		F-1	F-2	F-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	17.6	13.62	18.37	16.53	Jul-30	50	200
2	Potassium (K)	3.43	2.72	2.51	2.89	0.01-5	10	-
3	Magnesium (Mg)	7	5	9	7	Mar-15	50	-
4	Chloride	73	80	77	76.67	60-120	250	200-300
5	Fluoride	0.5	0.45	0.47	0.48	0.1-0.6	0.7	1.5
6	Nitrate	0.01	0.05	0.02	0.03	-	10	50
7	Nitrite	0.012	0	0.011	0.008	-	1	3
8	Sulphate	30	25	32	29	Oct-50	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.12	7.45	7.89	7.49	6.5-8.5	6.5-8.5	-
12	TDS	252.7	235.5	247.4	245.2	100-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	119	126	133	126.33	-	-	-
15	Salinity (PSU)	0.297	0.272	0.285	0.28	-	-	-
16	Total Hardness	95	84	103	94	-	-	500

Table 6 (b): Analytical results of brand F in October-November.

Source	DF	SS	MS	F	P
Treatment	15	207241	13816	846.51	0
Error	32	522	16.3		
Total	47	207763			
Grand Mean	37.869	CV	10.67		

Table 6(c): Completely randomized AOV for results.

Brand G

Brand G is the local brand of Lahore produced in the area of KotLakhpath. Total 3 samples of different batch numbers of this brand were analyzed. The results of sodium, potassium and magnesium were found satisfactory with respect to the specifications of PFA/PSQCA and WHO but two samples did not justify the results against the nutritional label of the brand. Potassium, nitrate and TDS of samples G-1 & G-2 found out of specs with respect to the nutritional label of the brand. Label shows the range from 0.2-1ppm in water for potassium while samples G-1&G-2 showed the result of 1.61 ppm & 1.13 ppm respectively. Moreover, label range of nitrate is <0.1ppm but sample G-1 result was 0.15ppm for nitrate. Whereas, the results of chloride, fluoride, nitrite and chlorine were parallel to the benchmark standards of PFA/PSQCA, WHO and also complied with the label specifications. Arsenic metal was not detected. Average pH and TDS was 7.31 and 142.7ppm respectively but

TDS results of samples G-1 &G-2 did not meet the specification range (TDS=150-300 ppm) mentioned in label. Likewise average value of salinity was 0.188PSU because it depends on TDS of the water. Turbidity of water was Zero. Moreover, average total hardness was 59.33 ppm while WHO recommends less than 500 ppm.

Sr.No	Tests	Results				Specifications as per		
		G-1	G-2	G-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	5.78	6.04	5.91	5.91	May-35	50	200
2	Potassium (K)	1.61	1.13	0.96	1.23	0.2-1	10	-
3	Magnesium (Mg)	11	8	7	8.67	Jan-15	50	-
4	Chloride	52	55	55	53.67	45-110	250	200-300
5	Fluoride	0.21	0.26	0.31	0.22	< 0.7	0.7	1.5
6	Nitrate	0.15	0.08	0.07	0.1	< 0.1	10	50
7	Nitrite	0	0	0	0	-	1	3
8	Sulphate	7	10	9	8.67	May-15	250	250
9	Chlorine	0	0	0	0	0	0.1	5
10	Arsenic	0	0	0	0	0	0.01	0.01
11	pH	7.38	7.09	7.45	7.31	6.5-8.5	6.5-8.5	-
12	TDS	132	144.5	151.6	142.7	150-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	40	38	46	41.33	-	-	-
15	Salinity (PSU)	0.179	0.189	0.195	0.188	-	-	-
16	Total Hardness	66	57	55	59.33	-	-	500

Table 7(a): Analytical results of brand G in June-July.

Sr.No	Tests	Results				Specifications As per		
		G-1	G-2	G-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	5.78	6.04	5.91	5.91	May-35	50	200
2	Potassium (K)	1.61	1.13	0.96	1.24	0.2-1	10	-
3	Magnesium (Mg)	11	8	7	8.67	Jan-15	50	-
4	Chloride	52	54	55	53.67	45-110	250	200-300
5	Fluoride	0.21	0.25	0.31	0.26	< 0.7	0.7	1.5

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6	Nitrate	0.15	0.08	0.07	0.09	< 0.1	10	50
7	Nitrite	0	0	0	0	-	1	3
8	Sulphate	7	10	9	8.67	May-15	250	250
9	Chlorine	0	0	0	0	0	0.1	5
10	Arsenic	0	0	0	0	0	0.01	0.01
11	pH	7.38	7.09	7.45	7.31	6.5-8.5	6.5-8.5	-
12	TDS	132	144.5	151.6	142.7	150-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	41	38	46	41.33	-	-	-
15	Salinity (PSU)	0.179	0.189	0.195	0.189	-	-	-
16	Total Hardness	66	57	55	59.33	-	-	500

Table 7(b): Analytical results of brand G October-November.

Source	DF	SS	MS	F	P
Treatment	15	65797.6	4386.51	440.56	0
Error	32	318.6	9.96		
Total	47	66116.2			
Grand Mean	20.585	CV 15.33			

Table 7(c): Completely randomized AOV for results.

Brand H

Brand H is a local brand of Lahore produced in the area of Bund Road, ThokarNiazBaig. Total 3 samples of different batch numbers of this brand were analyzed. The results of sodium, potassium and magnesium were found satisfactory with respect to the specifications of PFA/PSQCA and WHO but two samples did not justify the results against the nutritional label of the brand. Label shows the potassium range from 0.2-1ppm in water while the samples result were 1.81ppm and 1.33ppm in sampleH-1 &H-3 respectively. Whereas, the results of chloride, fluoride, nitrate, nitrite, sulphate and chlorine were parallel to the benchmark standards of PFA/PSQCA, WHO and also complied with the label specifications. Arsenic metal was not detected. Average pH and TDS was 7.27 and 166.77ppm respectively and also found in specification ranges mentioned in table. Likewise average value of salinity was 0.213PSU because it depends on TDS of the water. Turbidity of water was Zero. Moreover, average total hardness was 103.33ppm while WHO recommends less than 500ppm.

Sr.No	Tests	Results				Specifications As per		
		H-1	H-2	H-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	10.3	9.55	14.73	11.53	May-35	50	200
2	Potassium (K)	1.81	0.89	1.33	1.34	0.2-1	10	-

3	Magnesium (Mg)	5	7	4	5.33	Jan-15	50	-
4	Chloride	53	58	49	53.33	45-110	250	200-300
5	Fluoride	0.35	0.41	0.35	0.37	< 0.7	0.7	1.5
6	Nitrate	0.01	0.04	0.03	0.03	-	10	50
7	Nitrite	0	0	0.01	0.003	< 0.1	1	3
8	Sulphate	11	9	15	11.67	May-45	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.27	6.98	7.55	7.27	6.5-8.5	6.5-8.5	-
12	TDS	167.5	172.8	160	166.77	150-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	61	57	66	61.33	-	-	-
15	Salinity (PSU)	0.213	0.221	0.204	0.213	-	-	-
16	Total Hardness	103	109	98	103.33	-	-	500

Table 8(a): Analytical results of brand H in June-July.

Sr.No	**Tests**	**Results**				**Specifications as per**		
		H-1	**H-2**	**H-3**	**Average**	**Label**	**PFA/ PSQCA(MAC)**	**WHO**
		(ppm)	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**
1	Sodium (Na)	10.3	9.55	14.73	11.53	May-35	50	200
2	Potassium (K)	1.81	0.89	1.33	1.34	0.2-1	10	-
3	Magnesium (Mg)	5	7	4	5.33	Jan-15	50	-
4	Chloride	53	58	49	53.33	45-110	250	200-300
5	Fluoride	0.35	0.41	0.35	0.37	<0.7	0.7	1.5
6	Nitrate	0.01	0.04	0.03	0.03	-	10	50
7	Nitrite	0	0	0.01	0.003	<0.1	1	3
8	Sulphate	11	9	15	11.67	May-45	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.27	6.98	7.55	7.27	6.5-8.5	6.5-8.5	-
12	TDS	167.5	172.8	160	166.77	150-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	61	57	66	61.33	-	-	-

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15	Salinity (PSU)	0.213	0.221	0.204	0.213	-	-	-
16	Total Hardness	103	109	98	103.33	-	-	500

Table 8(b): Analytical results of brand H in October-November.

Source	DF	SS	MS	F	P
Treatment	15	102870	6857.97	830.26	0
Error	32	264	8.26		
Total	47	103134			
Grand Mean	26.407	CV 10.88			

Table 8(c): Completely randomized AOV for results.

Brand I

Brand I is the local brand of Lahore produced in the area of Sher Shah Road, Riwind. Total 3 samples of different batch numbers of this brand were analyzed. The results of sodium, potassium and magnesium were found satisfactory with respect to the specifications of PFA/PSQCA and WHO but one sample did not justify the sodium result against the nutritional label of the brand. Label shows the range from 7-30ppm in water for sodium while sample I-1 showed the result of 35ppm. Similarly, chloride results were totally out of specs with respect to specification range in label. Label shows the range from 77-150ppm in water for chloride while the results were 53ppm, 63ppm and 59ppm in samples I-1, I-2 &I-3 respectively. Moreover, two samples also showed deviation from the label range of sulphate, results of sulphate were 66ppm and 56ppm in samplesI-1 &I-3 while label shows the range of 12-50ppm for sulphate in water. Whereas, the results of fluoride, nitrite and chlorine were parallel to the benchmark standards of PFA/PSQCA, WHO and also complied with the label specifications. Arsenic metal was detected in one sample (0.01ppm) but did not exceed the maximum admissible limit by PFA/PSQCA and WHO. Average pH and TDS was 7.16 and 242.7 ppm respectively and also found in specification ranges mentioned in table. Likewise average value of salinity was 0.284PSU because it depends on TDS of the water. Turbidity of water was Zero. Moreover, average total hardness was 72 ppm while WHO recommends less than 500 ppm.

Sr.No	Tests	Results				Specifications as per		
		I-1	I-2	I-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	35	24	27	28.67	Jul-30	50	200
2	Potassium (K)	2.84	2.23	1.81	2.29	0.02-5	10	-
3	Magnesium (Mg)	4	9	6	6.33	Apr-15	50	-
4	Chloride	53	63	59	58.33	77-150	250	200-300
5	Fluoride	0.4	0.37	0.29	0.35	0.2-0.5	0.7	1.5
6	Nitrate	0.02	0.01	0.01	0.01	-	10	50
7	Nitrite	0	0	0	0	-	1	3
8	Sulphate	66	48	56	56.67	Dec-50	250	250
9	Chlorine	0	0	0	0	-	0.1	5

10	Arsenic	0.01	0	0	0.003	-	0.01	0.01
11	pH	7.03	7.51	6.95	7.16	6.5-8.5	6.5-8.5	-
12	TDS	241.9	236.5	249.7	242.7	150-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	90	106	88	94.67	-	-	-
15	Salinity (PSU)	0.286	0.274	0.291	0.284	-	-	-
16	Total Hardness	65	79	72	72	-	-	500

Table 9(a): Analytical results of brand I in June-July.

Sr.No	**Tests**	**Results**				**Specifications as per**		
		I-1	**I-2**	**I-3**	**Average**	**Label**	**PFA/ PSQCA(MAC)**	**WHO**
		(ppm)	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**	**(ppm)**
1	Sodium (Na)	35	24	27	28.67	Jul-30	50	200
2	Potassium (K)	2.84	2.23	1.81	2.29	0.02-5	10	-
3	Magnesium (Mg)	4	9	6	6.33	Apr-15	50	-
4	Chloride	53	63	59	58.33	77-150	250	200-300
5	Fluoride	0.4	0.37	0.29	0.35	0.2-0.5	0.7	1.5
6	Nitrate	0.02	0.01	0.01	0.01	-	10	50
7	Nitrite	0	0	0	0	-	1	3
8	Sulphate	66	48	56	56.67	Dec-50	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0.01	0	0	0.003	-	0.01	0.01
11	pH	7.03	7.51	6.95	7.16	6.5-8.5	6.5-8.5	-
12	TDS	241.9	236.5	249.7	242.7	150-300	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	90	106	88	94.67	-	-	-
15	Salinity (PSU)	0.286	0.274	0.291	0.284	-	-	-
16	Total Hardness	65	79	72	72	-	-	500

Table 9(b): Analytical results of brand I in October-November.

Source	**DF**	**SS**	**MS**	**F**	**P**
Treatment	15	180938	12062.5	574.29	0

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Error	32	672	21		
Total	47	181610			
Grand Mean	35.592	CV 12.88			

Table 9(c): Completely randomized AOV for results.

Brand J

Brand J is a renowned multinational brand and also certified with local & national regulatory bodies. Total3 samples of different batch numbers of this brand were analyzed. The results of sodium, potassium, magnesium, chloride, fluoride, nitrate, nitrite, sulphate and chlorine were parallel to the benchmark standard's ranges of PFA/PSQCA, WHO but the results did not exactly matched the nutritional label of the brand as the company did not mention the exact ranges or maximum/minimum admissible limit of the parameters mentioned in label. However, results of all the parameters found close to the targeted values mentioned in label.Arsenic metal was not detected. Average pH and TDS was 7.28 and 109ppm respectively and also found in specification ranges mentioned in table. Likewise average value of salinity was 0.158PSU because it depends on TDS of the water. Turbidity of water was Zero. Moreover, average total hardness was 52 ppm while WHO recommends less than 500 ppm.

Sr.No	Tests	Results				Specifications As per		
		J-1	J-2	J-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	13.6	14.3	13.9	13.93	13	50	200
2	Potassium (K)	1.18	1.32	1.86	1.45	1	10	-
3	Magnesium (Mg)	16	13	14	14.33	13	50	-
4	Chloride	22	25	24	23.67	20	250	200-300
5	Fluoride	0.14	0.25	0.22	0.2	-	0.7	1.5
6	Nitrate	0.02	0.01	0.04	0.02	< 0.1	10	50
7	Nitrite	0.004	0.006	0.002	0.004	-	1	3
8	Sulphate	54	58	52	54.67	52	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.43	6.89	7.52	7.28	6.5-8.5	6.5-8.5	-
12	TDS	106	109	112	109	105	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	7	3	5	5	-	-	-
15	Salinity (PSU)	0.153	0.159	0.162	0.158	-	-	-
16	Total Hardness	55	49	52	52	54	-	500

Table 10(a): Analytical results of brand J in June-July.

Sr.No	Tests	Results				Specifications as per		
		J-1	J-2	J-3	Average	Label	PFA/ PSQCA(MAC)	WHO
		(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
1	Sodium (Na)	13.6	14.3	13.9	13.93	13	50	200
2	Potassium (K)	1.18	1.32	1.86	1.45	1	10	-
3	Magnesium (Mg)	16	13	14	14.33	13	50	-
4	Chloride	22	25	24	23.67	20	250	200-300
5	Fluoride	0.14	0.25	0.22	0.2	-	0.7	1.5
6	Nitrate	0.02	0.01	0.04	0.02	< 0.1	10	50
7	Nitrite	0.004	0.006	0.002	0.004	-	1	3
8	Sulphate	54	58	52	54.67	52	250	250
9	Chlorine	0	0	0	0	-	0.1	5
10	Arsenic	0	0	0	0	-	0.01	0.01
11	pH	7.43	6.89	7.52	7.28	6.5-8.5	6.5-8.5	-
12	TDS	106	109	112	109	105	500	600
13	Turbidity (NTU)	0	0	0	0	-	0.5	0.5
14	Alkalinity	7	3	5	5	-	-	-
15	Salinity (PSU)	0.153	0.159	0.162	0.158	-	-	-
16	Total Hardness	55	49	52	52	54	-	500

Table 10(b): Analytical results of brand J in October-November.

Source	DF	SS	MS	F	P
Treatment	15	41310.3	2754.02	1483.39	0
Error	32	59.4	1.86		
Total	47	41369.7			
Grand Mean	17.712	CV 7.69			

Table 10(c): Completely Randomized AOV for Results

Analysis of microbiology of bottled water

Assessment of microbiological parameters for quality of bottled water was executed by membrane filtration method. Analyzed sample quantity was 100mL for each. 0.45µ filter paper was used to filter the microbes in the sample water. I have analyzed the water samples for the evaluation of Pathogenic Microbes e.g. (Coliforms, E.coli, Fecal Streptococcus, Pseudomonas aeruginosa), Total Plate Count, Yeast and Mold content in the bottled water. The evaluated results were compared with the specification ranges of PFA/PSQCA standard only because WHO does not define the microbial limit for the above stated microbial growth in drinking water.

Every brand was analyzed in triplicate and average result is considered. Results of brands A, B, C, D, E and J were negative for pathogenic microbes e.g. Coliforms, E.coli, Fecal

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Streptococcus and Pseudomonas aeruginosa. Similarly, TPC was zero for brands B & D while brands A, C, E and J were reported with minor growth on TPC plates but their CFU (Colony Forming Unit) counts existed within the specification range of PFA/ PSQCA. Yeast and Mold were not detected in these brands.

On the other side, brands F, G, H and I which were the local brands of Lahore reported with positive results for pathogenic microbes and also carry the huge CFU count for the TPC and Yeast in it.

Brand F results was positive for Coliforms, E.coli and Pseudomonas. TPC and Yeast was TNTC (Too Numerous To Count) while fecal streptococcus & mold growth were not detected.

Brand G average results for pathogenic microbes were positive. Coliforms (7.33 cfu), E.coli(5.33cfu) and Pseudomonas (38.33 cfu)per 100 mL of water sample. Similarly, average TPC result was 116.3cfu per 100 mL while yeast growth was too numerous to count. Fecal Streptococcus & Mold growth were not detected.

Brand H average results for pathogenic microbes were positive. Coliforms (7.33cfu), E.coli(4 cfu) and Pseudomonas(41.5 cfu) per 100 mL of water sample. Whereas, the growth on TPC and yeast plates were too numerous to count. Fecal streptococcus & mold growth were not detected. Brand I average results for Coliforms was 2.67 cfu per 100 mL of water sample. Similarly, average TPC count was 87 cfu per 100 mL while yeast growth was 32.5 cfu per 100 mL of water sample. E.coli, fecal streptococcus, pseudomonas & mold growth was not detected.

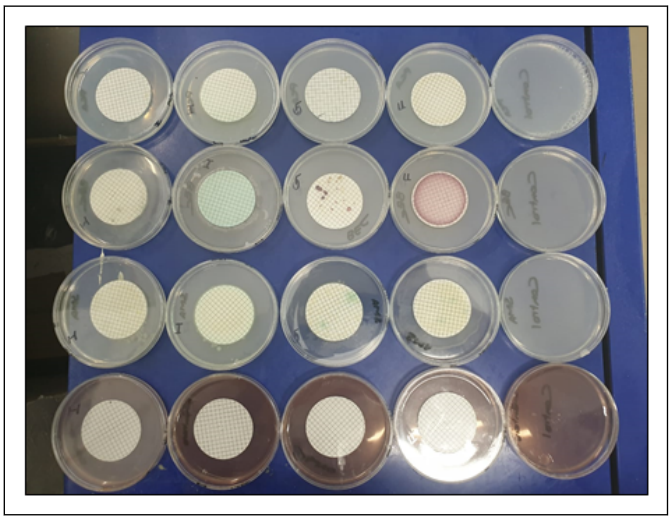

Figure 1: Local brands with positive microbial growth.

Brands		Tests						
Code	**Samples**	**Coliform**	**E.Coli**	**F. Streptococcus**	**Pseudomonas**	**TPC**	**Yeast**	**Mold**
A	A-1	0	0	0	0	0	0	0
	A-2	0	0	0	0	1	0	0
	A-3	0	0	0	0	0	0	0
	Average	0	0	0	0	0.33	0	0
B	B-1	0	0	0	0	0	0	0
	B-2	0	0	0	0	0	0	0
	B-3	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0
C	C-1	0	0	0	0	0	0	0
	C-2	0	0	0	0	0	0	0
	C-3	0	0	0	0	2	0	0
	Average	0	0	0	0	0.67	0	0
D	D-1	0	0	0	0	0	0	0
	D-2	0	0	0	0	0	0	0
	D-3	0	0	0	0	0	0	0
	Average	0	0	0	0	0	0	0
E	E-1	0	0	0	0	3	3	0
	E-2	0	0	0	0	0	0	0
	E-3	0	0	0	0	1	0	0

	Average	0	0	0	0	1.33	1	0
F	F-1	TNTC	TNTC	0	TNTC	TNTC	TNTC	0
	F-2	TNTC	TNTC	0	TNTC	TNTC	TNTC	0
	F-3	TNTC	TNTC	0	TNTC	TNTC	TNTC	0
	Average	-	-	0	-	-	-	0
G	G-1	7	5	0	38	124	TNTC	0
	G-2	6	6	0	45	129	TNTC	0
	G-3	9	5	0	32	96	TNTC	0
	Average	7.33	5.33	0	38.33	116.3	-	0
H	H-1	6	6	0	TNTC	TNTC	TNTC	1
	H-2	7	3	0	32	TNTC	TNTC	0
	H-3	9	3	0	51	TNTC	TNTC	0
	Average	7.33	4	0	41.5	-	-	0.33
I	I-1	2	0	0	0	TNTC	TNTC	0
	I-2	1	0	0	0	98	29	0
	I-3	5	0	0	0	76	36	0
	Average	2.67	0	0	0	87	32.5	0
J	J-1	0	0	0	0	0	0	0
	J-2	0	0	0	0	2	0	0
	J-3	0	0	0	0	0	0	0
	Average	0	0	0	0	0.67	0	0
Specifications As per PSQCA		0 cfu per 250 mL	0 cfu per 250 mL	0 cfu per 250 mL	0 cfu per 25 0mL	20 cfu per mL	-	-

On the basis of the above discussed results, I am also able to summarize the compliance percentage of the brands toward the pathogenic microbes, against the standard of PFA/PSQCA.

Total No. of Pathogenic Microbes Tested for each Brand (M) =4

No. of Replicates Performed (R) = 3

Total No. of Tests Performed for each Brand = M × R = 4 × 3 = 12

Brands	Total No. Of Tests	Tests with +ve Results	Tests with -ve Results	Compliance %age
A	12	0	12	100
B	12	0	12	100
C	12	0	12	100
D	12	0	12	100
E	12	0	12	100
F	12	9	3	25
G	12	9	3	25
H	12	9	3	25
I	12	3	9	75
J	12	0	12	100

Table 11: Total no. of tests performed for each brand.

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Conclusion

As I am concluding my research work in two sections; analytical and microbiological sections, I have concluded that there were no significant change of temperature in any property of water and the analytical section was more complied with PFA/PSQCA and WHO standards than that of the microbiological section either the brand is local, national or multinational. From all my results I have concluded that only 3 brands out of 10 were complying 100% with respect to the specification ranges mentioned in their label and also the standards of PFA/PSQCA and WHO. Most of the brands were showing deviation from the values of Na, K, Mg, sulphate and chloride mentioned in their label while all the analytical results found within the specification ranges of PFA/PSQCA and WHO. Change of Environmental Temperature i.e testing in June-July and October-November doesn't affect any property of bottled water and no mineral or chemical leached out. On the other hand, microbiological section was not so complied with PFA/PSQCA standards. All the six national and multinational brands were fully microbial free and have zero pathogenic microbial growth in sample water while four local brands of Lahore have showed positive results for the Total Coliforms, E.coli and Pseudomonas and also showed huge content of Yeast &Mold growth. Hence, by considering the results of both the sections I am able to explore that Brand D is fit to drink.

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