Research Article

Chemical and Microbial Analysis of Drinking Water of Different Localities in Rawalpindi

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Abstract | The aim of this study was to perform physico-chemical and microbial analysis of drinking water samples of different areas of Rawalpindi. The water samples were collected into sterile containers from the different localities of Rawalpindi such as Dhokekala khan, Morgah, Scheme-III, Gulshandadan khan, Satellite town, Dhoke kashmirian, Pandora, Bahria town, University campus (Mehr water) and Air Port. The pH of PMAS-AAUR campus water (Mehr Water) was found within WHO recommended values (pH limit 6.5-8.5) whereas the pH of other water samples were ranged from 7.3-8.9.The salts values of Mehr Water were determined as Calcium 58mg/l, Sulphate 48mg/l, Sodium26mg/l, Magnesium13mg/l,Chloride150mg/l, Alkalinity 147 mg/l and total dissolved solids176mg/l were found according to WHO recommended limits. The values of Calcium 89mg/l, Magnesium 52mg/l, Chloride 342mg/l, and ions like Sulphate 412mg/l of Dhokekala khan, Morgah, Scheme-III, and Bahria town, respectively were not found according to WHO and PSQCA recommended limits. The Microbial analysis of Mehr water showed that water was free of mould, yeast, *E.coli,* total coliform and bacterial contamination. The water samples of Dhoke kashmirian, Pandora Satellite town, and Gulshan dadan khan indicated coliform, yeast and bacterial contamination which caused water-borne diseases such as Dysentry, Diarrhea and Typhoid fever.

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Introduction

Water is one of the most important of all natural resources known on earth. It is important to all living organisms, most ecological systems, human health, food production and economic development (Postel et al., 1996). Water of good drinking quality of basic importance to human physiology of man's continued existence depends very much on its availability (Shrivastava et al., 2013; Sundar et al.,2015). Only 1% part is available on land for drinking, agriculture, domestic power generation, industrial consummation, transportation and waste disposal (Gupta et al., 2008; Tahir et al., 2008; Yadav et al., 2011). Fresh water is the most important resources, that are crucial for the survival of living beings. It is necessary for the human being as they depend upon it for production of food, industrial and waste disposal, as well as cultural requirement (Akpoveta et al., 2011). Water quality means the physical, chemical and biological characteristics of water (Diersing, 2009).

The first edition of standard methods was published in 1905. Since then it has been considered to be the best available guidance of water analysts, which covers all aspects of water and wastewater analysis techniques and categorizes the analytical methods based on the constituent and not on the type of wa-

ter (APHA, 2012). Many congenital diseases such as goiter and cancer have been associated with presence of high concentration of a chemical or its inadequate supply in water. Opinya et al. (1987) reported that low or high level of fluoride ions concentration in water as the major cause of dental flurosis. Water is life and life is fully dependent on the economical status now a days. In present study economically cities have been chosen to determine their water quality. In India, about 70% of the existing water is contaminated, out of which 84-92% water is contaminated by sewage pollution and 8-16 % water by industrialized pollution and others (Manwar et al., 2014).

To maintain disease free normal life, it is very necessary to be concerned about quality of water which needs to be potable as per the WHO and Indian Standards. Currently, about 20% of the world's population lacks access to safe drinking water, and more than 5 million people die annually from illness associated with safe drinking water or inadequate sanitation. If everyone had safe drinking water and adequate sanitation services, there would be 200milion fewer cases of diarrhea and 2.1 million fewer deaths caused by diarrheal illness each year (Hunter et al., 2001). The quality of water from these sources is variable, but usually in some areas it may contain huge amounts of nitrates and this is of particular concern (Van Vuuren, 2013). A number of morphological and biochemical parameters have been used to facilitate in determining the identities of fecal contaminating bacteria in water (Wose Kinge et al., 2010; Ateba et al., 2011). The natural water analysis for physical and chemical properties including trace element contents is very important for public health studies (Arunabh and Vasishta, 2008).

The increased use of metal-based fertilizer in revolution of agricultural could result in the form of continued rise in metal pollutions concentration in fresh water reservoir owing to the water run-off. Also pollution of drinking water create water born disease that caused death of millions of people (Adefemi and Awokunmi, 2010). Several water analyses have been regularly conducted by different scientific groups across the country. Water used for drinking, cleaning fish and ice-making must be free from pathogenic bacteria and may require secondary treatment or even complete treatment depending on chemical elements that need to be removed. Treatment of raw water to produce water of potable best quality is done by different process. Impurities in the water are removed through a process of coagulation, filtration and chlorination. Flocculation and coagulation will assist in removing contaminants in the water, causing turbidity, colour odour and taste which cannot be removed by sedimentation alone. Reverse osmosis (RO) is used to receive saline water and changed it into pure water. It currently forms 80% desalination plants for a cumulative and 44% of desalinated volume of water (Greenlee et al., 2009). The quality of surface and ground water is deteriorating day by day throughout country. The discharge of industrial and domestic wastewater into open water bodies is the major threat to the country's water reserves. The issue is becoming dangerous and very serious as open water-bodies; like streams lakes and rivers, being increasingly contaminated. Water quality is characterized by its physical, chemical and biological composition. The biological characteristics for water quality are very importance in the control of diseases that are caused by pathogenic organisms of human origin. (Hassan M. and S. Hanif, 2014).

The resultant precipitate can be removed by sedimentation and filtration. Indirect irradiation by various lamps to accomplish its target of deactivation that depend on variety and scope of microbes involved. The classification of Ultra Violet lamps is medium-pressure polychromatic lamps and low-pressure monochromatic lamps, and there has been recently introduction of pulsed UV lamps (Bohrerova et al., 2008). PMAS-AAUR installed mineral water plant called Mehr Water to provide fresh and best quality water to all students and faculties. The people who use this water for drinking purposes are extreme liable to fatal diseases. So, it is very important to control and analyze the quality of water on all parameters. This is about the pollution and drinking water quality of Rawalpindi district compared with its sources (Hassan, M. and S. Hanif, 2014).

The objectives of the present study were to check physico-chemical and microbial parameters of drinking water samples collected from the selective localities of Rawalpindi. The aim was to assess health impact linked with the consumption of unsafe drinking water and to suggest accurate and safe drinking water.

Materials and Methods

The experiments were carried out at the quality control laboratories of PMAS-AAUR. The ten water samples were collected from different localities of Rawalpindi

such as Dhokekala khan, Morgah, Scheme-III, Gulshandadan khan, Satellite town, Dhoke kashmirian, Pandora, Bahria town, Mehr water and Air Port as shown in the Table 1. The water samples were collected into sterile 5 litres plastic container after the tap was allowed to run for 5 minutes. The collected water samples were analyzed for physico-chemical and microbiological analysis. The procedure for analysis was followed as per standard methods of analysis of water (Pariha et al., 2012).

Table 1: *Location of drinking water samples selected for analysis.*

Sample No	Source	Location
1	Mehr water	PMAS-AAUR University Campus (MW)
2	Tap water	Dhokekala khan (DKK)
3	Tap water	Dhoke Kashmirian (DHK)
4	Tap water	Gulshandadan khan (GDK)
5	Tap water	Morgah (MOR)
6	Tap water	Bahria town (BHR .T)
7	Tap water	Satellite town (SATE.T)
8	Tap water	Air Port (AIR.PT)
9	Tap water	Pandora (PNDO)
10	Tap water	Scheme-III (SCHM.III)

Physico-Chemical parameters

pH determination: The pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity (Gupta, 200). At the same time the temperature of sample determined. After the indicated value remains constant for about 1 min the reading is taken. After each measurement, the electrode of pH meter (least count ± 0.01 pH) was washed with distilled water. (Anwar K. et al., 2011). At the time of collection, the pH of all water samples of Rawalpindi areas were measured by using pH meter (model china and least count ± 0.01 pH). The calibration was done by two standard buffer solutions of pH 4.0 and 7.0.

Total dissolved solid: The water sample (50ml) is filtered through ordinary filter paper and water is collected in the evaporating dish of known weight. Then heated and water is evaporated completely. Whatever dissolved solid matter is present gets accumulated at the bottom of evaporating dish. After this evaporating dish is cooled and weighed. The total dissolved solid is determined by weight difference method.

Alkalinity: Water sample (100ml) was placed in a conical flask and then added a few drop of methyl orange indicator in it. The magnetic stirrer was then put in the conical flask with its content. This was stirred magnetically while a burette was filled with N/50 HCL, and this was titrated against the water sample (100ml) in the conical flask (Balogun, 2000).

Total hardness

Water sample(100ml) was poured in a conical flask, and then two drops of Erichrome-T indicator was dropped into the water sample. After that a drop of buffer-9 (i.e amino chloride and amino sulphate) was also added on the conical flask contents. A burette was filled with N/50 Ethylene diamine tetra acetic acid (EDTA.) and then titrated against the water sample in the conical flask.

Calcium and magnesium hardness

Water sample (100ml) was placed in a conical flask and two drops of murexide indicator was dropped on the contents of the conical flask. Buffer -12 (NaOH) was added to the contents of the conical flask. A burette filled with N/50 EDTA was titrated against the water (100ml) in the conical flask (Balogun, 2000). Deduced by obtaining the difference between the values of total hardness and Calcium hardness of each water sample (Balogun, 2000).

Chloride and sulphate

It is measured by titrating a known volume of sample with standardized silver nitrate solution using potassium chromate solution in water or eosin/fluorescein solution in alcohol as indicator. The latter indicator is an adsorption indicator while the former makes a red colored compound with silver as soon as the chlorides are precipitated from solution.

It is measured by nephelometric method in which the concentration of turbidity is measured against the known concentration of synthetically prepared sulphate solution. Barium chloride is used for producing turbidity due to barium sulphate and a mixture of organic substance (Glycerol or Gum acetia) and sodium chloride is used to prevent the settling of turbidity.

Sodium determination

It is measured with the help of flame photometer (model no U.K/PFP-7 Jenway Ltd). The instrument is standardized with the known concentration of sodium ion (1 to 100 mg/litre). The samples having

higher concentration are suitably diluted with distilled water and the dilution factor is applied to the observed values.

Isolation of micro-organisms

Membrane filtration technique was used to isolate the microorganisms present in the water samples. The funnel of the membrane filtration unit has a capacity of 50ml and the funnel was mounted one receptacle fixed to the vacuum pump which allows the water to flow over the porous sterile membrane filter (0.45µm). Aseptically, the membrane filters were placed on each microbial growth medium using sterile forceps after passage of 100ml of water sample. The following media (McConkey agar, Plate count agar, potato dextrose agar, Levine Eosin Methylene blue agar and Lauryl tryptosebroth) were prepared and autoclaved at 121^{0}C for 15 minutes by using autoclave(Japan/HVA-110 Hirayama manufauteuring corp) before being inoculated with membrane filters(APHA, 1992; Anonymous, 1982).

Total coliform

Lauryl tryptose broth was used for detection of total coliforms. For each dilution, triplicate tubes of LT broth were made and 10 ml was added in each tube with the inverted fermentation tubes or dhurum or in it. Caps of tubes were kept loosen. Medium and other apparatus were autoclaved by using autoclave (Japan/HVA-110 Hirayama). Then One ml sample dilution was taken and added in respectively labeled medium tubes. All these tubes were kept in incubator at 35 for 48 hours. Tubes examined for production of gas that causes medium dislocation in dhurum tubes. Tubes with negative result were reincubated for 24 hours more(APHA, 1992; Balogun, 2000).

Determination of E. Coli (Escherichia coli)

For *E. coli*, the medium Levine Eosin Methylene blue agar was used. Medium was prepared with distilled water in loosen cap reagent bottle. Then sterilized it by autoclaving and cool down to temperature up to 45˚C- 50˚C.About 25ml medium was poured in the plates, then allowed them to solidify. From positive EC tubes, the loopfull of suspension was streaked on Levine Eosin Methylene blue agar (LEMB) plates. Incubation was done at 35 ˚C for 18 to 24 hours and then plates were examined for *E. coli* colonies i.e. colonies with dark centers which may or may not have metallic shine. Plate Count Agar slants prepared by preparing medium, 20 about 10 ml added in each tube, autoclaved by using autoclave (Japan/HVA-110 Hirayama with loosen caps. After autoclaving, tubes were kept at slant position to agar solidified as such to form slants. Typical colonies were collected from LEMB plates and then transferred to PCA slants for confirmatory steps. Slants were given incubation by incubator (Germany/WIG-50) at 35 ˚C for 18 to 24 hours**.**

Isolation of total bacteria

Water sample was filtered with the help of sterile membrane filter (0.45/µm). Then it was placed in an empty sterile Petri-dish by method aerobic plate count using plate count agar incubated at 37˚C for 24hrs (APHA, 1992; Balogun, 2000).

Aerobic Plate Count (APC): Medium was autoclaved and used for aerobic plate count. 1ml of sample from each dilution was taken and added into respectively labeled sterilized 15 ×100mm petri plates and then 20 ml of plate count agar medium was poured. Then immediately medium and sample dilution both was mixed uniformly by rotating clockwise and anticlockwise and allowed to solidify. By this way triplicate plates were prepared for each dilution and incubated inverted for 48 hours at 35˚C.After incubation, Colonies were counted by colony counter. Consecutive triplicate plates showing 25 to 250 colonies were taken, then multiplied by total count of colonies by inverse of dilution. Result reported as number of organism per gram of food. If only one diluton was in range, average of count per gram was taken for dilution and described as APC per g. If two or more dilution were in range, average count of dilution was calculated before taking average of count of 2 dilution to attain the result.

Isolation of yeast and moulds

The 100ml of water sample was filtered by a sterile membrance filter (0.2/µm). The membrane filter was placed aseptically on Potato Dextrose Agar (PDA) and then incubated by incubator (Germany/WIG-50) at 22˚C for 48hrs (APHA,1992; Balogun, 2000). For yeast to determine, Plate Count Agar medium with Chloramphenicol was used to stop the bacterial growth. For moulds, Potato Dextrose Agar (PDA) was used with 10% tartaric acid in it. Media were prepared and antibiotic was added in Plate Count Agar by syringe and filtering from 0.45um membrane, then sterilized and cooled to about 45˚C in water bath. After this 10 % sterilized tartaric acid added to adjust pH

of PDA to 3.5 optimum for growth of moulds. Then 25 ml of medium was poured in relabeled 15×100mm Petri plates and allowed the medium to solidified. 0.1 ml of sample dilutions was added in each labeled petri plates and sample was spread by glass spreader. Triplicates for each dilution was prepared and incubated in dark, undisturbed for 5 days at 22 °C to 25°C.

Results and Discussion

pH of different water samples

The pH value of water samples taken from the different places of Rawalpindi ranges from 7.3 to 8.9 as shown in Table 2. The Gulshandadan khan and Morgah water samples showed maximum pH 8.9 and minimum pH 7.3 values, respectively. The pH values of Mehr water (pH 7.9), Morgah (pH 7.3) and Airport (pH 7.5) lies within the range of PSQC (6.9-8.5). These studies showed that pH values of some water samples such as Pandora (pH 8.8), Scheme- III (pH 8.6) and Dhokekala khan (pH8.7) exceed the limits set by WHO standard range (6.5-8.5) (Figure 1).

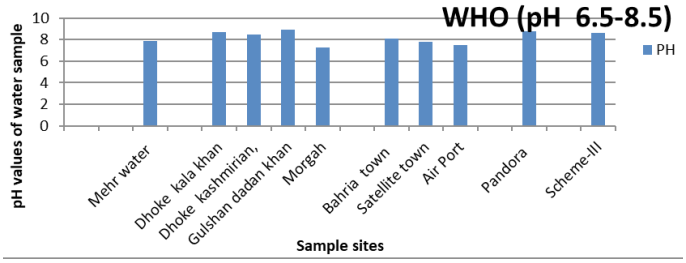

Figure 1: *pH in Drinking Water Samples.*

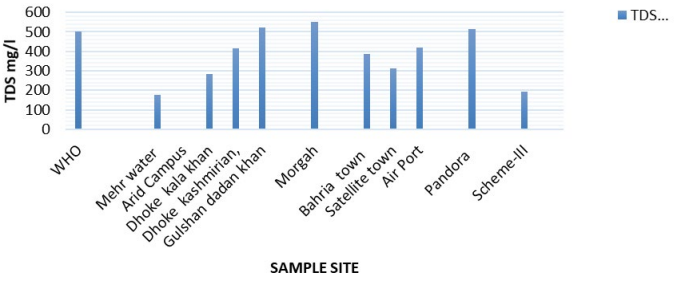

Figure 2: *Total dissolved solids in drinking water samples.*

Total dissolved solids (TDS) and alkalinity

The total dissolved solids values of water sample taken from different places of Rawalpindi were ranges from (176 mg/l to 551 mg/). Mehr water showed best value of TDS (176 mg/l) that is best for drinking. The TDS of Gulshandadan khan, Morgah and Pandora drinking water samples exceed the limit set by WHO (500 mg/l) as shown in Table 2. The result showed that the drinking water of Scheme- III 192 mg/l, Dhokkala khan 284 mg/l, satellite town 311 mg/l suitable for drinking as shown in Figure 2. The alkalinity range set by WHO is 200mg/L. The minimum alkalinity 147 mg/l found in Mehr water and maximum alkalinity 321 mg/l found in Gulshandadan khan as shown in Figure 3.

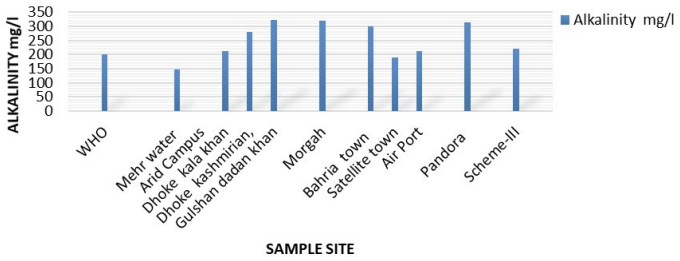

Figure 3: *Alkalinity in drinking water samples.*

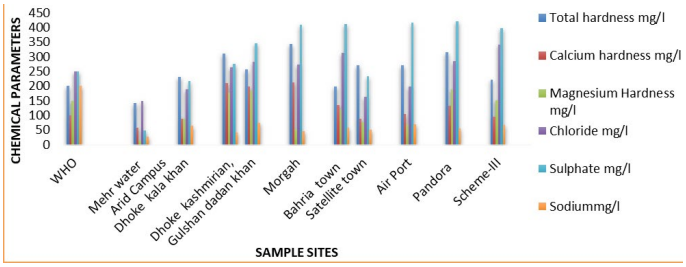

Figure 4: *Comparison of chemical parameters in drinking water samples.*

Chemical parameters

The minimum value 58 mg/L of calcium hardness and maximum value 213 mg/l of calcium hardness found in Mehr water and Morgah water samples, respectively. The magnesium hardness values of water sample collected from different localities of Rawalpindi were ranged from (13 mg/l to 189 mg/l) as given in Table 2. Mehr water indicated magnesium value 13 mg/l and Calcium 58 mg/l value. The calcium and magnesium hardness values of different areas of Rawalpindi were compared with WHO standard values of Calcium and Magnesium hardness as shown in Figure 4. The maximum Chloride value 342 mg/l and minimum chloride value 150mg/L found in water sample of scheme III and university campus respectively lies standard range of PSQCA. So high chloride value in water cause problems in after sewerage. Excess amount also changes taste of drinking water and make it saline. The chloride values of Dhokkala khan, Mehr water, Satellite town and Air port water sample fall within recommended range of WHO and PSQCA. Satellite town, mehr water and Dhokkala khan water sample contained sulphate concentration 234 mg/l,48 mg/l, 216 mg/l respectively as shown in Table 2. The sodium values of different water sample collected from different areas of Rawalpindi were ranged from 26 mg/l to 74 mg/l. The water

Table 2: *Analysis of physico- chemical parameters (mg/L) of drinking water samples of different localities in Rawalpindi, reference to WHO standards.*

Sr.no	Sample sites	PH	TDS mg/l	Alkalinity mg/l	Total hardness mg/l	Calcium hardness mg/l	Magnesium Hardness mg/l	Chloride mg/l	Sulphate mg/l	Sodi-ummg/l
	WHO	6.5-8.5	500	200	200	100	150	250	250	200
1	Mehr water Arid Campus	7.9	176	147	141	58	13	150	48	26
2	Dhokekala khan	8.7	284	212	232	89	88	190	216	65
3	Dhoke kashmirian,	8.5	414	279	310	210	176	264	276	41
4	Gulshandadan khan	8.9	521	321	258	198	185	282	345	74
5	Morgah	7.3	551	319	343	213	52	274	410	45
6	Bahria town	8.1	387	299	198	134	121	313	412	57
7	Satellite town	7.8	311	189	272	89	77	164	234	51
8	Air Port	7.5	419	211	270	105	69	198	417	69
9	Pandora	8.8	512	313	315	132	189	285	421	56
10	Scheme-III	8.6	192	219	221	96	151	342	398	67

Table 3: *Microbial species detected in the drinking water sample (number per 100ml) of different localities in Rawalpindi.*

Sr.No	Sample sites	Plate count agar Number/100ml	Yeasts Number/100 ml	Moulds Number/100ml	Total Coliform Number/100ml	E.Coli Number/100ml
1	Mehr water Arid Campus	5	2	1	0	0
2	Dhokekala khan	11	12	10	1	2
3	Dhoke kashmirain,	29	21	11	7	3
4	Gulshandadan khan	31	17	13	9	5
5	Morgah	21	13	19	5	7
6	Bahria town	25	11	17	4	1
7	Satellite town	28	19	15	6	0
8	Air Port	19	14	9	2	4
9	Pandora	35	16	14	8	6
10	Scheme-III	26	9	10	4	0

sample of Gulshandadan khan, Scheme -III and air port showed sodium values of 74 mg/, 67 mg/l and 69 mg/l respectively that compete the standard values of PSQCA. The estimated mineral values of different areas of Rawalpindi were compared with WHO standard values of the chloride, sulphate and sodium values as shown in Figure 4.

Result of microbial analysis

High microbial counts in water are undesirable because of the increased likelihood that pathogens may be present, the possibility that these organisms will find access to foods and drink. Thereby causing spoilage and the adverse effects such organisms may have on pipelines and processing equipment. High coliform counts were the most common reason for the failure of potable water (Le Chevallier et al., 1996). Although, it may sometimes be necessary to seek specific pathogens in water in response to epidemiological investigation following outbreaks of water-borne diseases of coliform, *E. coli* and bacterial contamination.

For determination of APC in water sample, dilution plates containing colonies in range of 25 to 250 are selected. Sample of Mehr water, Dhokekala khan, Morgah and Air port showed 5, 11, 21 and 19 colonies of APC in dilution plates respectively as given in Table 3. All these mean values of APC are ignored because numbers of colonies did not fall in the range (25-250). Due to less value of APC Mehr water is free of APC and safe for drinking. Lauryl tryptose tubes showed no contamination after 48 hours. All these tubes were re-incubated at 35◦C for again 48 hours. No growth and gas production were seen in all tubes during confirmatory tests. Total coliform and *E, coli* is absent in water sample of Mehr water plant be-

cause its value is zero according to WHO and PSQC values. The water sample of Gulshan dadan khan and Morgah indicated presence of Total coliform and *E.Coli* as shown in Figure 5.

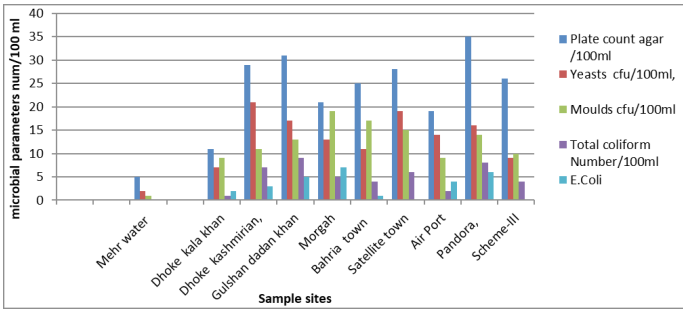

Figure 5: *Comparison of microbial parameters in drinking water samples.*

The dilution plates having colonies in range of 10 to 150 are selected for determination of yeast and mould count in water sample. All dilution plates of Mehr water sample showed yeast and moulds colonies in very less number i.e. less than 10. All these values did not fall within range 10-150. So that Mehr Water is free of yeast, moulds and fungus spores. But water samples of Dhoke kashmiran, Gulshandadan khan, Bahria town, Pandora and Satellite showed yeast and mould colonies because their values fall within range 10-150 as shown in Table 3. Water Safety plan requires that risks to drinking-water safety are identified, checked, prioritized and managed to save the quality of drinking-water before problems occuring. It also requires regular monitoring of control measures parameters and confirmation of water quality.

Conclusions and Recommendations

The research study was conducted to perform physico-chemical and microbial analysis of drinking water samples collected from different sites of Rawalpindi. The pH values of PMAS-AAUR campus water (Mehr Water), Morgah water and Air port water was found within WHO recommended values (pH limit 6.5-8.5) and PSQC recommended values (pH limit 6.9-8.5). The TDS of Gulshandadan khan, Morgah and Pandora drinking water samples exceed the limit set by WHO (500 mg/L). Mehr water and Scheme III showed best values of TDS (176 mg/L) and (192 mg/l), respectively that is best for drinking. The minimum alkalinity 147 mg/L found in Mehr water and maximum alkalinity 321 mg/L found in Gulshandadan khan. The maximum value 213 mg/L of Calcium hardness found in Morgah water samples. The chloride values of Dhokkala khan, Mehr water, Satellite town and Air port water sample fall within recommended range of WHO. Satellite town, Mehr water and Dhokkala khan water sample contained sulphate concentration 234 mg/L,48 mg/L, 216 mg/L respectively. The water samples of Dhoke kashmirain, Gulshandadan khan, Bahria town, Pandora and Satellite showed yeast and mould colonies because their values fall within range 10-150 that are selected for determination of yeast and mold count in water samples. All dilution plates of Mehr water sample showed no yeast and molds colonies. So, it is assumed that Mehr Water is safe and perfect for drinking because it is free of *E. coli,* total coliform, yeast, moulds and fungus spores.

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Author's Contribution

Hina Ali: Data collection, concieved idea, analysis parameter performed, abstract and methodology conclusion.
Iram Shaheen: Data collection, data entry and sample collection.
Feroza Hamid Wattoo: Review and corrections

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