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QUALITY EVALUATION OF DRINKING WATER IN DARRA ADAM KHEL, KHYBER PAKHTUNKHWA

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Abstract

Research work was conducted to find out microbial and physiochemical characteristics of (Bore and Tube well) water in the coal mines mountainous terrain of Darra Adam Khel. A total fourteen number of samples with three replicates were taken from seven villages (Bazi Khel, German Kaly, Qasam Khel, Suni Khel, Feroz Khan Mela, Toor Khel and Akhoor wall) and were checked for the effect of coal mines on drinking water. Samples were evaluated for pH, Electrical conductivity (EC), Total dissolved solids (TDS), Carbonates, Bicarbonates, Calcium, Magnesium, Chlorides, Hardness, Heavy metals (Zinc, Iron, Copper, Lead, Manganese and Chromium) and total coliform. Physiochemical analyses showed that pH in range of 7.4 to 7.9, Total dissolved solids was 260.67mg/l to 476.67mg/l, Electrical conductivity was 39.83µS/cm to 76.30µS/cm, Carbonates was 38.3mg/l to 97.67mg/l, Bicarbonates was 136.3mg/l to 197.3mg/l, Calcium was 22.80mg/l to 95.86mg/l, Magnesium was 55.79mg/l to 97.29mg/l, Chlorides was 69.35mg/l to 182.00mg/l and Hardness was 262mg/l to 458mg/l. Heavy metals such as zinc was 0.017mg/l to 0.067mg/l, copper was 0.008mg/l to 0.096mg/l, manganese was 0.030mg/l to 0.386mg/l, lead was 0.12mg/l to 1.82mg/l, chromium was 1.13mg/l to 8.16mg/l and iron were in range of 0.016mg/l to 0.113mg/l. Total coliform was 0 MPN/ 100 ml to 210 MPN/ 100 ml. The results showed that pH, TDS, EC, Carbonates, Bicarbonates, Hardness, Magnesium, Chloride, Zinc, Iron, Copper, Manganese were in the safe level according to PSI and WHO level. While some samples of Calcium, Lead, Chromium and total Coliform count were above WHO recommended level and making it unfit for drinking purpose.

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Introduction

Water is one of very significant source of overall naturally occurring resources on earth. Water is necessary for continued existence and for the survival of human beings, all living organisms, ecological system, for fruits and vegetable and for the economic development of a country. Drinking of risk free and dirt free water is recommended and a fundamental right of human being. To keep the standard of water and keep this quality control is the basic theme in many parts of the world (WHO, 2011).

Water found in nature in abundant form and is widely distributed substance. Overall there is about 1400 million billion liters of water, in which the majority of the water is not used for consumption purpose since most of it (97%) is ocean water and the remaining 3% is clean water of which 2% is in the Antarctic ice caps and glaciers so the percentage of available water for portal use is 1% (Khalid *et al.* 2011). Mainly the usage of water for humans depends upon ambient quality (Jafari *et al.* 2008). Almost 1% of water is for consumption of human, household, agriculture purpose, industrial purpose, shipping and waste disposal (Lui *et al.* 2000).

Presently water that is used as a house hold is generally known as the domestic water. That water should be process to reach in a safe and proper condition and use as a drinking or it is utilized for other purposes. Water purity and its stability can be judge by sensory evaluation and the numbers of organic and inorganic properties (Dissmeyer *et al.* 2000). The presence of any sort of contamination in the water can influence the excellence of water and it directly affects the person healthiness. The main contamination sources of water are ecological conditions, the industrialized wastes plus agriculture actions and water management plants. The contamination is additionally subdivided as microorganisms, organic and inorganic, radionuclide and disinfectants (Nollet, 2000).

Water possess some unique properties i.e. colorless, odorless, tasteless and free of any sort of smell. Essential for botanical (plant) and zoological (animal) life. Water change to solid form at 0ºC (32ºF) while the boiling temperature is 100ºC (212ºF). At 4ºC the specific gravity of water is 1.0000 (Bacha *et al.* 2010).

The inorganic chemicals have the greater ability than that of organic chemicals to hold a large part of containments in drinking water (Azrina *et al.* 2011). Rapid rise of industries can pollute water sources which has a basic problem for humans.

In developing countries like Pakistan such kind of environmental issues has a threat for peoples (Ghoochani *et al.* 2011, Mohammad *et al.* 2012). Further the existence of poisonous and radioactive elements i.e. uranium presence in ground water is a further severe problem in several countries of the world which is high level of chemical toxicity and has negative impact on human skeleton and kidney (Katsoyiannis and Zouboulis, 2013). Ground water has significant and vital role on human life and the effect of industrialization and urbanization has the main sources of the water spoilage (Nagamani, 2015).

Acceptance of underground water is depended on chemical properties of geographical location of an area (Aston, 2001). Pyrite generally present in coal strata of mines and found three times higher as compared to its existence in rocks which tend to form sulphate, heavy metals, also it can lower pH of water and can develop many variation in surrounding environment (Usher *et al.* 2003). Changes in water can be observed in pH as well as EC because of acidic and alkaline drainage from mines along with hazard components and metals to surrounding (Meck *et al.* 2006).

Coal mine has a great effect on the environment and is of a special concern, because it will lead to the acidification of surface water bodies. Usually mining require some technique to keep the environment from its effects (Kopezinski, 2000). Water pollution is because of explored areas which cannot be rehabilitated this be mostly due to acid mine drainage (AMD), because of pyrite oxidation (FeS_2). In the presence water and oxygen pyrite produce a vast concentration of sulfuric acid which can dissolves metals (Asta *et al.* 2008; Rose and Cravotta, 1998).

Pakistan gifted with a large number of coal reserves but it cannot produced that much coal because lack of required facilities, non-availability of modern machinery and poverty of peoples.

Also a very less work has been done that not adequate information is available although such areas have a vast possibility of new microorganisms (Roohi *et al.* 2014). In areas like Darra Adam Khel also huge quantity of coal reserves were explored (Malkani, 2012).

As Darra Adam Khel containing coal reserves which has huge impact on surrounding environment and also no information is available about drinking water of the study area so, a key purpose of work was to test out overall valuable parameters of drinking water at selected areas in Darra Adam Khel near coal mines.

Materials and methods

Drinkable water samples near coal mines were the focus of study. Samples were collected from seven villages of Darra Adam Khel, having coal mines and were analyzed in the Laboratory of Food Science and Technology, Department of Soil and Environmental Sciences, The University of Agriculture Peshawar and Govt. Public Health Food Analysis Laboratory Hayatabad.

Sterilization of the bottles

Bottles were purchased from the local market of Peshawar. The entire bottle was washed with antiseptic and sterilized with hot water and dried.

Samples collection

Water samples from bore and tube well were collected from seven villages of Darra Adam Khel (Bazi Khel, German Kaly, Qasam Khel, Suni Khel, Feroz Khan Mela, Toor Khel and Akhoor Waal).The bottle was previous washed and extra care should be taken during the sampling. The samples then transfer to the laboratory.

Triplications

From both sources the triplication were taken to avoid any sort of error during the analysis. Mean value of replicates were considered as a standard.

Physiochemical analysis

Determination of pH

The pH of all collected water samples was determined by pH meter by following standard method of AOAC (2012). Buffer solutions having pH of 4 and 9 was used to standardize the pH meter. Samples were taken in a beaker and pH was noted as probe was dipped in the beaker.

Electrical conductivity

Electrical conductivity of the entire sample was determined by using EC meter as describe by method of AOAC (2012). Calibration of EC meter was done at room temperature (25°C) as the probe was dipped in samples reading was recorded.

Total Dissolved Solids

TDS of all the water samples were finding out by using TDS meter as per standard set by (AOAC, 2012).

Determination of carbonates (CO_3^{-2}) ion

Carbonates of the gathered samples were dictated by standard technique for checking of water and waste water (APHA, 2005), 10ml of water test was taken in a conical flask and phenolphthalein (2-3) drops was included as a pointer that changed shading to pink. The arrangement was titrated then against 0.01 N H_2SO_4 until the pink shading changed to colorless and perusing was noted and final value was determined by following equation.

$$\text{Carbonate} = \frac{\text{burette reading} \times 0.01\,N\,\text{H2SO4} \times 50 \times 1000}{\text{Volume of sample}}$$

Determination of Bicarbonate ($HCO3^-$) ion

Bicarbonates of gathered samples was dictated by standard strategy for the checking of water and waste water (APHA, 2005), 10ml of water test was taken in a conical flask and methyl orange (2-3) drops was included as a marker that changed shading to light yellow. The arrangement was titrated then against 0.01 N H_2SO_4 until the pink shading changed to pale yellow and perusing was noted and last reading of bicarbonate was determined by following formula.

$$\text{Bicarbonate} = \frac{\text{burette reading} \times 0.01\ N\ H2SO4 \times 50 \times 1000}{\text{Volume of sample}}$$

Hardness

25 ml sample was taken in a flask; 2ml buffer solution was added to it. Shake and afterward include Erichrome dark T, was included. Shake and titrated against EDTA taken in burette. Utilized volume was noted.

$$\text{Hardness} = \frac{\text{VL} \times \text{M} \times 100 \times 1000}{\text{ml of samples}}$$

Calcium

25 ml of test was taken in a flask. At that point buffer was included and shaken and putted Muroxidet, shaken and titrated against EDTA and note the utilized volume.

$$\text{Calcium} = \frac{\text{VL} \times \text{M} \times 100 \times 1000}{\text{ml of samples}}$$

Magnesium

Magnesium was found out by distinction among hardness and calcium.

Magnesium= (Total hardness – Calcium) × 0.24

Chlorides

Chlorides were determined by utilizing APHA 2005 technique for the assessment of gathered samples.

20 ml sample was taken in flask and 2-3 drop potassium chromate was included which give yellow color. Sample was then titrated against 0.0282 N $AgNO_3$ until black red color comes, noted burette reading.

Heavy metals

Gathered samples were determined for substantial metals in water utilizing atomic spectrophotometer (Model Perkin Elmer 2380 USA) keeping standard technique of AOAC (2012). 10 ml of sample was taken and added 90 ml distilled water so as to make 100 ml water sample and were investigated for heavy metals.

Microbial analysis

Gathered samples were checked down for microbial load of coliform following (MPN) Most Probable Number.9221, strategy for (Arnold 1992).

MacConkey broth was utilized as culture media for Total Coliform count. Media was set up by taking 4gm of MacConkey broth and mix up in 100 ml of distilled water.

Durham cylinder was put in each test tube. 10 ml sample was appropriated in 15 test cylinders and cotton plugs for each example and sanitized at 121°C for 25 mints. 10 ml, 1 ml and 0.1 ml of water test was added to 15 test tubes with 5 containers of each samples and fixed with cotton connects and were kept for 24 hours and temperature was balanced at 30 to 37°C and after that checked for contamination.

After brooding period positive cylinders were included in each arrangement of five test cylinders and proper number from MPN table (Tandon *et al.* 2005).

Statistical analysis

Complete randomized design (CRD) up to two ways was used as an experimental design using Statistix version 8.1. LSD was performed for mean value separation (Steel and Torrie 1997).

Results and discussion

pH

Table 2 showed pH of water taken from different areas of Darra Adam Khel having coal mines. pH of the sample were B_1(7.7), T_1(7.9) from Bazi Khel area, B_2(7.9), T_2(7.6) from German Kaly area, B_3(7.6), T_3(7.5) from Qasam Khel area, B_4(7.4), T_4(7.6) from Suni Khel area, B_5(7.4), T_5(7.6) from Feroz Khan Mela area, B_6(7.8), T_6(7.6) from Toor Khel area, B_7(7.6), T_7(7.6) from Akhoor Waal area. Highest mean value of pH concentration 7.9 was recorded in German Kaly bore water, while lowest mean value 7.4 was reported in Suni Khel, Feroz Khan Mela bore water and Bazi Khel tube well water. pH value 7.4 was almost observed in three location (Bazi khel Tube well water, Suni Khel and Feroz Khan Mela bore water). The pH was observed in safe range (6.5-8.5) set by (WHO, 2011).

Table 1. Proposed plan of study for research work.

Samples	Area	Sources
B_1	Bazi Khel	Bore water
T_1		Tube well water
B_2	German Kaly	Bore water
T_2		Tube well water
B_3	Qasam Khel	Bore water
T_3		Tube well water
B_4	Suni Khel	Bore water
T_4		Tube well water
B_5	Feroz Khan Mela	Bore water
T_5		Tube well water
B_6	Toor Khel	Bore water
T_6		Tube well water
B_7	Akhoor Waal	Bore water
T_7		Tube well water

Table 2. pH of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	6.5-8.5
Bazi Khel	7.7bc	7.4f	
German Kaly	7.9a	7.6de	
Qasam Khel	7.6de	7.5ef	
Suni Khel	7.4f	7.6cd	
Feroz Khan Mela	7.4f	7.5ef	
Toor Khel	7.8b	7.6cd	
Akhoor Waal	7.6cd	7.6cd	
Mean	7.6a	7.5b	

Values having different letters are significantly ($p < 0.05$) different from each other.

Statistical analysis showed that the area, sources and interaction had significant ($P<0.05$) effect on pH of water samples from different areas of Darra Adam Khel. A small change in drinking water pH is due to composition of constituent normally found in Ionic forms, that is hydrogen (H^+) and hydroxyl ions (OH^-) found in water. PH ranges from 0 to 14 in which 7 is neutral below it goes toward acidity while above it goes to alkalinity and generally pH in range of 6.5 to 8.5 is best and recommended. During mining when pyrites are oxidized it can lead pH to acidity, while also possibility that pH moves toward alkaline condition because of calcite in coal strata also all mines are acidic but it can be neutral as well as alkaline (Scharer *et al.* 2000).As pH was observed in recommended level so no effect has been observed here. Estvao *et al.* (2017) observed pH value ranges from 7.01 to 7.8 while assessing quality of coal mine water.

Electrical conductivity

Table 3 showed Electrical Conductivity of water taken from different areas of Darra Adam Khel having coal mines. Electrical Conductivity of the sample wereB_1(39.83µS/cm), T_1(55.50µS/cm) from Bazi Khel area, B_2(51.86µS/cm), T_2(64.44µS/cm) from German Kaly area, B_3(62.16µS/cm), T_3(61.84µS/cm) from Qasam Khel area, B_4(62.16µS/cm), T_4(61.84µS/cm) from Suni Khel area, B_5(46.20µS/cm), T_5(67.03µS/cm) from Feroz Khan Mela area, B_6(43.96µS/cm), T_6(73.13µS/cm) from Toor Khel area, B_7(54.10µS/cm), T_7(67.66µS/cm) from Akhoor Waal area. The highest value for EC 76.30µS/cm was recorded in Feroz Khan Mela Bore water, while the lowest mean value 39.80µS/cm was recorded in Bazi Khel Bore Water. EC in Toor Khel bore water and Feroz Khan Mela was almost same and EC of Qasam Khel was same for both sources.

Table 3. Electrical conductivity of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	1000 µS/cm
Bazi Khel	39.83h	55.50e	
German Kaly	51.86f	64.44cd	
Qasam Khel	62.16d	61.84d	
Suni Khel	46.20g	67.03bc	
Feroz Khan Mela	76.30a	43.30g	
Toor Khel	43.96g	73.13a	
Akhoor Wall	54.10ef	67.66b	
Mean	53.48b	61.84a	

Values having different letters are significantly ($p < 0.05$) different from each other.

Table 4. TDS content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	500 mg/l
Bazi Khel	323.33e	311.67fg	
German Kaly	311.67fg	297.00hi	
Qasam Khel	347.00d	315.33ef	
Suni Khel	476.67a	422.00b	
Feroz Khan Mela	296.33hi	277.00j	
Toor Khel	367.00c	340.67d	
Akhoor Wall	260.67k	305.33gh	
Mean	340.38a	321.33b	

Values having different letters are significantly ($p < 0.05$) different from each other.

Statistical analysis showed that the area, sources and interaction had significant ($P<0.05$) effect on electrical conductivity of water samples. Electrical Conductivity is total soluble salts within liquid solution. Pure water has zero conductivity rates because it does not possess any sort of salt. Additions of elements make it possible to pass through solution and give it a conductivity rate (Dhirendra *et al.* 2009). Normally natural water possesses low conductivity but contamination increases its level of conduction (Truman *et al.* 1995). Coal mines has the possibility to change pH, EC as well as heavy metal concentration (Meck *et al.* 2006). No effect of coal mines has been observed as EC is in safe range. Alhamed and Stefan (2014) reported conductivity in the range of 360-762 µS/cm during assessment of coal effects on water.

Total Dissolved Solids

Table 4 showed values of TDS of water taken from different areas of Darra Adam Khel having coal mines. TDS of samples were B_1(323.33mg/l), T_1(311.67mg/l) from Bazi Khel area, B_2(311.67mg/l), T_2(297mg/l) from German Kaly area, B_3(347mg/l), T_3(315.33mg/l) from Qasam Khel area, B_4(476.67mg/l), T_4(422mg/l) from Suni Khel area, B_5(296.33mg/l), T_5(277mg/l) from Feroz Khan Mela area, B_6(367mg/l), T_6(340.67mg/l) from Toor Khel area, B_7(260.67mg/l), T_7(305.33mg/l) from Akhoor Waal area. The highest value for TDS concentration 476.67mg/l were recorded in Suni Khel Bore water, while lowest260.67mg/l was observed in Akhoor Wall Bore Water. TDS of Feroz Khan Mela Bore water and German Kaly Tube well water was almost similar to each other.

Table 5. Carbonates content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	133mg/l
Bazi Khel	59.67e	83.00a	
German Kaly	90.00b	57.67ef	
Qasam Khel	69.67d	53.00g	
Suni Khel	97.67b	45.33g	
Feroz Khan Mela	78.00c	89.00b	
Toor Khel	59.33e	66.67d	
Akhoor Wall	45.33g	38.33h	
Mean	71.38a	61.85b	

Values having different letters are significantly ($p < 0.05$) different from each other.

Table 6. Bicarbonates content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	300 mg/l
Bazi Khel	168.3cd	62.0g	
German Kaly	142.3f	136.3f	
Qasam Khel	155.3e	160.6de	
Suni Khel	177.6b	168.3cd	
Feroz Khan Mela	169.6c	160.3e	
Toor Khel	161.6de	136.6f	
Akhoor Wall	136.3f	197.3a	
Mean	158.7a	160.2b	

Values having different letters are significantly ($p < 0.05$) different from each other.

Statistical analysis showed that the area, sources and interaction had significant ($P<0.05$) effect on TDS of water samples. Total dissolved solids an essential parameter of water for usage. High number of TDS shows that it is extremely mineralized. According to Pakistan Standards Quality Control Authority 500 mg/l is the allowable limit (Hussain *et al.* 2012). Acidic coal mines generally increases its level in water (Tiwary *et al.* 2001). All of samples were at safe level for TDS concentration as no effect of coal mines was observed. In a similar study Yadav and Jamal (2018) found TDS were of 65-1650 mg/l during assessing water quality in coal mines.

Carbonates

Table 5 showed carbonates of water taken from different areas of Darra Adam Khel having coal mines. Carbonates of samples wereB_1(59.67mg/l), T_1(83mg/l) from Bazi Khel area, B_2(90mg/l), T_2(57.67mg/l) from German Kaly area, B_3(69.67mg/l), T_3(53mg/l) from Qasam Khel area, B_4(97.67mg/l), T_4(45.33mg/l) from SuniKhel area, B_5(78mg/l), T_5(89mg/l) from Feroz Khan Mela area, B_6(59.33mg/l), T_6(66.67mg/l) from Toor Khel area, B_7(45.33mg/l), T_7(38.33mg/l) from Akhoor Waal area.. The highest mean value for Carbonates concentration 97.67mg/l were recorded in Suni Khel bore water, while lowest mean value 38.3mg/l was noted in Akhoor Wall Tube well Water.

There is a little difference in between the values of bicarbonates in German Kaly Bore with Feroz Khan Mela Tube well, Bazi Khel Bore with Toor Khel Bore and Akhoor Waal Bore with Suni Khel Tube well water. Recommended level of carbonates is 133mg/l by PSI (Pakistan Standard Institute).

Table 7. Calcium content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	75 mg/l
Bazi Khel	75.7b	68.8b	
German Kaly	95.8a	53.8cd	
Qasam Khel	94.6a	54.6cd	
Suni Khel	48.4de	58.7f	
Feroz Khan Mela	29.4g	37.3f	
Toor Khel	22.8g	44.3ef	
Akhoor Wall	47.6de	52.6cd	
Mean	59.2a	52.9b	

Values having different letters are significantly ($p < 0.05$) different from each other.

Statistical analysis showed that the area, sources and interaction had significant ($P<0.05$) effect on carbonates of samples. Normally in water carbonates and bicarbonates occurred with each other in solution, with pH and CO_2. At pH 8.3 the existence of carbonates is indicated, while below 8.3 pH carbonates are changed equally to bicarbonates (Patil *et al.* 2012).

As our results is in satisfactory range for carbonates mean no effect of coal mines. Alhamed and Stafen (2005) found no existence of carbonate in his work.

Table 8. Magnesium content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	150 mg/l
Bazi Khel	60.0d	57.3d	
German Kaly	58.5d	65.3cd	
Qasam Khel	55.7d	65.6cd	
Suni Khel	97.2a	91.1ab	
Feroz Khan Mela	62.6d	56.5d	
Toor Khel	66.0cd	66.4cd	
Akhoor Wall	57.9d	78.6bc	
Mean	65.4a	68.7a	

Values having different letters are significantly ($p < 0.05$) different from each other.

Bicarbonates

Table 6 showed values of bicarbonates concentration of water taken from different areas of Darra Adam Khel having coal mines. Bicarbonates of samples were B_1(168.33mg/l), T_1(62mg/l) from Bazi Khel area, B_2(142.3mg/l), T_2(136.3mg/l) from German Kaly area, B_3(155.3mg/l), T_3(160.6mg/l) from Qasam Khel area, B_4(177.6mg/l), T_4(168.3mg/l) from Suni Khel area, B_5(169.6mg/l), T_5(160.3mg/l) from Feroz Khan Mela area, B_6(161.6mg/l), T_6(136.6mg/l) from Toor Khel area, B_7(136.3mg/l), T_7(197.3mg/l) from Akhoor Waal area.. The highest mean value for bicarbonates concentration 197.3mg/l was recorded in Akhoor Wall Tube well water, while lowest mean 136.3mg/l was observed also in Akhoor Wall Bore Water. Similarity has been existing in Akhoor Waal, Toor Khel Bore water as well as German kaly Tube well along with Qasam Khel Tube well water. Recommended level for Bicarbonates is 300 mg/l by Pakistan Standard Institute (PSI, 1987).

Table 9. Hardness content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	500mg/l
Bazi Khel	393.3b	357.3cd	
German Kaly	364.3bc	331.3def	
Qasam Khel	310.6f	322.6ef	
Suni Khel	458.0a	363.6bc	
Feroz Khan Mela	325.3ef	317.3f	
Toor Khel	342.3cdef	351.0cde	
Akhoor Wall	262.6g	395.3b	
Mean	350.9a	348.3a	

Values having different letters are significantly ($p < 0.05$) different from each other.

Statistical analysis showed that the area, sources and interaction had significant ($P<0.05$) effect on bicarbonates of collected samples. Bicarbonates a natural part of mineral waters. No rules and regulation regarding bicarbonates are their but its highest permissible range in drinking water is 300mg/l. All the results were in recommended level and confirmed no specific effect of coal mines on water bodies. Its level are varies in water due to weathering of rocks which contain many minerals i.e. calcium along with magnesium responsible for its higher level in drinking water (Mehmood *et al.* 2013). Bicarbonates useful for keeping acid and base in body and act as a vital opponent for acids (Nasir *et al.* 2012). Alhamed and Stefan (2014) observed bicarbonates as low as 5.4 mg/l while checking standard of water Bochum Germany near coal reserves.

Table 10. Chlorides content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	200mg/l
Bazi Khel	96.2f	99.7f	
German Kaly	100.9f	144.1c	
Qasam Khel	103.7f	168.0b	
Suni Khel	115.0e	125.3d	
Feroz Khan Mela	119.2de	113.9e	
Toor Khel	182.0a	180.9a	
Akhoor Wall	69.3g	69.4g	
Mean	112.3b	128.8a	

Values having different letters are significantly ($p < 0.05$) different from each other.

Calcium

Table 7 showed values of calcium concentration of water taken from different areas of Darra Adam Khel having coal mines. Calcium of water utilized for drinking were B_1(75.7mg/l), T_1(68.8mg/l) from Bazi Khel area, B_2(95.8mg/l), T_2(53.8mg/l) from German Kaly area, B_3(94.6mg/l), T_3(54.6mg/l) from Qasam Khel area, B_4(48.4mg/l), T_4(58.7mg/l) from Suni Khel area, B_5(29.4mg/l), T_5(37.3mg/l) from Feroz Khan Mela area, B_6(22.8mg/l), T_6(44.3mg/l) from Toor Khel area, B_7(47.6mg/l), T_7(52.6mg/l) from Akhoor Waal area. Highest mean value for calcium concentration 95.86mg/l was recorded in German Kaly bore water, while the lowest mean 22.80mg/l was noted in Toor khel Bore Water. Mean values of calcium concentration for sources (Bore water and Tube well water) were 59.21mg/l and 52.91mg/l correspondingly. Calcium permissible level is 75 mg/l. Calcium was in safe limit except for Bazi Khel, German Kaly and Qasam Khel Bore water. Similar values were observed in German Kaly and Qasam Khel Bore water samples.

Table 11. Zinc content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	3 mg/l
Bazi Khel	0.02cd	0.01d	
German Kaly	0.02d	0.04b	
Qasam Khel	0.01d	0.05ab	
Suni Khel	0.02d	0.01d	
Feroz Khan Mela	0.06a	0.02d	
Toor Khel	0.01d	0.04b	
Akhoor Wall	0.04bc	0.02cd	
Mean	0.03a	0.03a	

Values having different letters are significantly ($p < 0.05$) different from each other.

Statistical analysis showed that the area, sources and interaction had significant ($P<0.05$) effect on calcium of collected samples. In water calcium are present naturally, mostly it is found in large proportion in earth crust and can dissolve from rocks. Kumar *et al.* (2006) stated that a high changes in calcium concentration from same geographical area, as mineral concentration is highly different from each other. Sikakwe (2017) reported calcium ranged between 6.01 to 20.2mg/l in Nigeria.

Magnesium

Table 8 showed magnesium concentration of water taken from different areas of Darra Adam Khel having coal mines. Magnesium of water samples utilized for drinking wereB_1(60mg/l), T_1(57.3mg/l) from Bazi Khel area, B_2(58.5mg/l), T_2(65.3mg/l) from German Kaly area, B_3(55.7mg/l), T_3(65.6mg/l) from Qasam Khel area, B_4(97.2mg/l), T_4(91.1mg/l) from Suni Khel area, B_5(62.6mg/l), T_5(56.5mg/l) from Feroz Khan Mela area, B_6(66mg/l), T_6(66.4mg/l) from Toor Khel area, B_7(57.9mg/l), T_7(78.6mg/l) from Akhoor Waal area.

Statistical analysis showed that the area had significant ($P<0.05$) effect on magnesium of collected samples. While sources along with interaction had significant no effect on magnesium of sample. Highest mean value for magnesium concentration 97.29mg/l was noted in Suni Khel bore water, while the lowest mean value 55.79mg/l was noted in Qasam Khel Bore Water. The mean values of magnesium concentration from different sources (Bore water and Tube well water) were 65.47 mg/l and 68.72 mg/l respectively. Recommended level of magnesium in drinking water is 150 mg/l by WHO. Similar values were recorded in German Kaly and Toor Khel Tube well water. Magnesium a common constituent of fresh water responsible for water hardness. Dolomite is basic source of magnesium (NSDWQ, 2008).

Table 12. Copper content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	1.00 mg/l
Bazi Khel	0.01b	0.01b	
German Kaly	0.01b	0.008b	
Qasam Khel	0.01b	0.03b	
Suni Khel	0.01b	0.15a	
Feroz Khan Mela	0.02b	0.02b	
Toor Khel	0.09ab	0.01b	
Akhoor wall	0.01b	0.009b	
Mean	0.027a	0.017a	

Values having different letters are significantly ($p < 0.05$) different from each other.

It should be in recommended level otherwise it can cause digestive system problems (Daud *et al.* 2017). Usher *et al*, 2003 observed magnesium out of range during checking quality of water of mining areas.

Hardness

Table 9 revealed hardness concentration of water taken from different areas of Darra Adam Khel having coal mines. Hardness of water samples utilized for drinking were B_1(393.3mg/l), T_1(357.3mg/l) from Bazi Khel area, B_2(364.3mg/l), T_2(331.3mg/l) from German Kaly area, B_3(310.6mg/l), T_3(322.6mg/l) from Qasam Khel area, B_4(458mg/l), T_4(363.6mg/l) from Suni Khel area, B_5(325.3mg/l), T_5(317.3mg/l) from Feroz Khan Mela area, B_6(342.3mg/l), T_6(351mg/l) from Toor Khel area, B_7(262.6mg/l), T_7(395.3mg/l) from Akhoor Waal area. The highest mean value for hardness concentration 458mg/l was noted in Suni Khel bore water, while lowest mean 262mg/l was noted in Akhoor Wall bore Water.

The mean values of hardness concentration from different sources (Bore water and Tube well water) were 350.95mg/l and 348.38mg/l correspondingly. Bazi Khel bore water and Akhoor Waal Tube well water has same like values for hardness.

Table 13. Manganese content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	0.5 mg/l
Bazi Khel	0.38a	0.20d	
German Kaly	0.30b	0.03e	
Qasam Khel	0.33ab	0.05e	
Suni Khel	0.19d	0.04e	
Feroz Khan Mela	0.22cd	0.08e	
Toor Khel	0.38a	0.27bc	
Akhoor wall	0.24cd	0.04e	
Mean	0.29a	0.10b	

Values having different letters are significantly ($p < 0.05$) different from each other.

Statistical analysis witnessed that the area and interaction had significant ($P<0.05$) effect on hardness of collected samples, while sources has no effect. Normally water hardness mean carbonates and bicarbonates of magnesium and calcium ions which are important and most available common minerals present in water ultimately lead to increase hardness. According to WHO drinking water should contain hardness lower than 500mg/l (Dhanaji *et al.* 2016). Similarly Javid *et al.* (2012) reported hardness from 153.6-427.2mg/l range while evaluated quality of drinking water in Mardan.

Chlorides

Table 10 reveled chlorides of water taken from different areas of Darra Adam Khel having coal mines. Chlorides of water samples utilized for drinking wereB_1(96.2mg/l), T_1(99.7mg/l) from Bazi Khel area, B_2(100.9mg/l), T_2(144.1mg/l) from German Kaly area, B_3(103.7mg/l), T_3(168mg/l) from Qasam Khel area, B_4(115mg/l), T_4(125.3mg/l) from Suni Khel area, B_5(119.2mg/l), T_5(113.9mg/l) from Feroz Khan Mela area, B_6(182mg/l), T_6(180.9mg/l) from Toor Khel area, B_7(69.3mg/l), T_7(69.4mg/l) from Akhoor Waal area. Highest mean value for chloride 182.00mg/l was noted in Toor Khel Bore water, while the lowest mean value 69.35mg/l was noted in Akhoor Wall Bore Water.

Table 14. Iron content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	0.2 mg/l
Bazi Khel	0.01f	0.05cde	
German Kaly	0.11a	0.08abc	
Qasam Khel	0.03def	0.09abc	
Suni Khel	0.03def	0.06bcd	
Feroz Khan Mela	0.09ab	0.04def	
Toor Khel	0.02f	0.02ef	
Akhoor Wall	0.03def	0.04def	
Mean	0.03a	0.05a	

Values having different letters are significantly ($p < 0.05$) different from each other.

Both sources of Toor Khel water have almost same chlorides value. The mean values of chloride from different sources (Bore water and Tube well water) were 112.37mg/l and 128.80mg/l respectively. 200mg/l is the acceptable range for chloride so all the samples was in the allowable range.

Statistical analysis showed that the area, sources and interaction had significant ($P<0.05$) effect on chloride of collected samples. Generally in drinking water chloride come from industrial effluents, natural sources, urban runoff having salt and intrusion of saline and sewage (Solanki, 2012).

Similarly Yadav and Jamal (2018) stated chloride mainly change from place to place because of geochemical environment. The presence of chloride ions gives salty taste to water. They observed chlorides 65 to 1650 mg/l during assessing quality parameters of water in coal mines. No effect of coal mines on drinking water has been observed.

Zinc

Table 11 showed zinc of water taken from different areas of Darra Adam Khel having coal mines. Zinc of water samples utilized for drinking were B_1(0.02mg/l), T_1(0.01mg/l) from Bazi Khel area, B_2(0.02mg/l), T_2(0.04mg/l) from German Kaly area, B_3(0.01mg/l), T_3(0.05mg/l) from Qasam Khel area, B_4(0.02mg/l), T_4(0.01mg/l) from Suni Khel area, B_5(0.06mg/l), T_5(0.02mg/l) from Feroz Khan Mela area, B_6(0.04mg/l), T_6(0.02mg/l) from Toor Khel area, B_7(0.03mg/l), T_7(0.03mg/l) from Akhoor Waal area. Highest mean value for zinc concentration 0.067mg/l was noted in Feroz Khan Mela bore water, while lowest value 0.017mg/l was noted in Toor Khel Bore Water.

The mean values of zinc from different sources (Bore water and Tube well water) were 0.030mg/l and 0.032mg/l correspondingly. According to WHO zinc permissible level are 3.0mg/l. The whole sample was in safe range.

Table 15. Lead content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	0.01 mg/l
Bazi Khel	0.22g	0.99c	
German Kaly	0.54ef	1.31b	
Qasam Khel	0.71cde	1.00c	
Suni Khel	0.60de	0.13g	
Feroz Khan Mela	0.20g	0.85cd	
Toor Khel	0.29fg	1.82a	
Akhoor Wall	0.07g	0.12g	
Mean	0.37b	0.89a	

Values having different letters are significantly ($p < 0.05$) different from each other.

Statistical analysis showed that the area had significant ($P<0.05$) effect on zinc of collected samples, while sources had no significant effect on zinc of collected samples. Zinc an important nutrient for human body. Its presence in higher range in water can produce different health problems. Zinc with 5 mg/l will start to give chalky looks with a clear change in taste (Nawab *et al.* 2016). Kumar (2015) recorded zinc in safe range while checking impact of coal on water in Odisha state India. Similarly no effect has been observed as water has normal range of zinc.

Copper

Table 12 showed copper of water taken from different areas of Darra Adam Khel having coal mines. Copper of water samples utilized for drinking wereB_1(0.01mg/l), T_1(0.01mg/l) from Bazi Khel area, B_2(0.01mg/l), T_2(0.008mg/l) from German Kaly area, B_3(0.01mg/l), T_3(0.03mg/l) from Qasam Khel area, B_4(0.01mg/l), T_4(0.1mg/l) from Suni Khel area, B_5(0.02mg/l), T_5(0.02mg/l) from Feroz Khan Mela area, B_6(0.09mg/l), T_6(0.01mg/l) from Toor Khel area, B_7(0.01mg/l), T_7(0.009mg/l) from Akhoor Waal area. Highest mean value for copper 0.09mg/l was noted in Toor Khel Bore water, while lowest value 0.008mg/l was noted in German Kaly tube well water. The mean values of copper concentration in drinking water from Bore water and Tube well water were 0.027mg/l and 0.017mg/l respectively. Whole samples were in safe limit as the acceptable level of copper is 1.0mg/l and no effect of coal mines is observed.

Statistical analysis showed that the area, sources and interaction had no significant ($P<0.05$) effect on copper of collected samples. Copper generally present in low concentration in water and high level may be due to industries application and mining which is main reason in environment to pollute the surface and ground water (Gautum *et al.* 2014).

Wei *et al.* (2018) checking impact of mining on heavy metals in Headwater in China and observed copper in safe level that is 0.009 – 0.693mg/l.

Manganese

Table 13 showed manganese of water taken from different areas of Darra Adam Khel having coal mines. Manganese of water samples utilized for drinking wereB_1(0.38mg/l), T_1(0.20mg/l) from Bazi Khel area, B_2(0.30mg/l), T_2(0.03mg/l) from German Kaly area, B_3(0.33mg/l), T_3(0.05mg/l) from Qasam Khel area, B_4(0.19mg/l), T_4(0.04mg/l) from Suni Khel area, B_5(0.22mg/l), T_5(0.08mg/l) from Feroz Khan Mela area, B_6(0.38mg/l), T_6(0.27mg/l) from Toor Khel area, B_7(0.24mg/l), T_7(0.04mg/l) from Akhoor Waal area. Highest mean value for manganese 0.38mg/l was noted in Toor Khel Bore water, while lowest value 0.03mg/l was noted in German Kaly tube well water. Mean values of manganese concentration in drinking water samples of Bore water and Tube well water were 0.29mg/l and 0.10mg/l respectively and vary from each other. According to EPA 0.5 mg/l is the safe level for manganese.

Table 16. Chromium content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	0.5mg/ l
Bazi Khel	3.96bcd	3.36bcd	
German Kaly	3.36bcd	3.53bcd	
Qasam Khel	2.80cde	1.13e	
Suni Khel	5.16b	4.56bc	
Feroz Khan Mela	2.70de	4.36bcd	
Toor Khel	` 5.13b	8.16a	
Akhoor wall	5.06b	3.76bcd	
Mean	4.02a	4.12a	

Values having different letters are significantly ($p < 0.05$) different from each other.

Statistical analysis showed that the area, sources and interaction had significant ($P<0.05$) effect on manganese of collected samples. Normally manganese presents as a mineral and obtains from rocks and sediment or may due to mining process and industrial waste (Reddy *et al.* 2012).Presence of higher level of it then recommended level has severed health effects (WHO, 2004). Mn concentrations of the samples collected were within the range of WHO threshold of 0.5 mg/l. No effect of coal mines has been observed in water as all the samples fallen in recommended level. Mn concentrations in range of 0.25- 0.38mh/l were noted by Adaikpoh *et al.* (2005) in Nigeria during checking metals in coal mines.

Iron

Table 14 showed iron of water taken from different areas of Darra Adam Khel having coal mines. Iron of water samples utilized for drinking wereB_1(0.01mg/l), T_1(0.05mg/l) from Bazi Khel area, B_2(0.11mg/l), T_2(0.08mg/l) from German Kaly area, B_3(0.03mg/l), T_3(0.09mg/l) from Qasam Khel area, B_4(0.03mg/l), T_4(0.06mg/l) from Suni Khel area, B_5(0.09mg/l), T_5(0.04mg/l) from Feroz Khan Mela area, B_6(0.02mg/l), T_6(0.02mg/l) from Toor Khel area, B_7(0.03mg/l), T_7(0.04mg/l) from Akhoor Waal area. Highest mean value for iron concentration 0.11mg/l was noted in German Kaly bore water, while lowest mean value 0.01mg/l was noted in Bazi Khel Bore water. Mean values of iron concentration in drinking water samples from Bore water and Tube well water were 0.03mg/l and 0.05mg/l correspondingly. 0.2 is the limit of iron in drinking water set by WHO. So all the samples were at safe level for iron and no effect of coal mines on water has been observed.

Statistical analysis showed that the area and interaction had significant ($P<0.05$) effect on iron of collected samples, while source. Normally iron originates naturally in water. Iron is beneficial for good wellbeing of human, useful for keeping metabolism and stop anemia. In water it is occur from industrial waste, iron ores and natural deposit (WHO, 2004). Howladar *et al.* (2014) noted iron in range of .75 to 1.50mg/l during checking water quality near coal mines.

Lead

Table 15 showed values of lead concentration in bore and tube well water taken from different areas of Darra Adam Khel having coal mines. Lead of water samples utilized for drinking were inB_1(0.22mg/l), T_1(0.99mg/l) from Bazi Khel area, B_2(0.54mg/l), T_2(1.31mg/l) from German Kaly area, B_3(0.71mg/l), T_3(1.00mg/l) from Qasam Khel area, B_4(0.60mg/l), T_4(0.13mg/l) from Suni Khel area, B_5(0.20mg/l), T_5(0.85mg/l) from Feroz Khan Mela area, B_6(0.29mg/l), T_6(1.82mg/l) from Toor Khel area, B_7(0.07mg/l), T_7(0.12mg/l) from Akhoor Waal area. Highest mean value for lead concentration 1.82mg/l was noted in Toor Khel Tube well water, while lowest mean value 0.120mg/l was noted in Akhoor Wall tube well water. Mean values of lead concentration in drinking water from Bore water and Tube well water were 0.37mg/l and 0.89mg/l respectively. 0.01 is the safe level for lead according by WHO. Almost all the sample was contaminated.

Statistical analysis showed that the area, sources and interaction had significant (P<0.05) effect on lead of collected samples. Heavy metals such as lead and mercury enter to atmosphere due to highly pollution and activity of industries which deposits in soil near water reservoir and enter those (Wang *et al.* 2015).

Mining which are normally possess more waste of metals can badly affect quality of water bodies on any surface. Significant side effects of some metals like zinc, copper, lead; cadmium has been observed which effect overall ecosystem (Environment Agency, 2008). Presence of lead from recommended level may have severe side effects on health (Storelli *et al.* 2005). In similar study done in china in which almost the whole samples were in safe level (Fang *et al.* 2018).

Table 17. Total Coliform content of drinking water from selected areas and sources of Darra Adam Khel.

Area name	Source		WHO Level
	Bore water	Tube well water	0 MPN/ 100ml
Bazi Khel	106.3b	0.00c	
German Kaly	0.00c	5.33c	
Qasam Khel	0.66c	5.33c	
Suni Khel	0.00c	0.66c	
Feroz Khan Mela	4.33c	210.0a	
Toor Khel	0.00c	0.00c	
Akhoor wall	0.00c	0.00c	
Mean	15.9b	31.6a	

Values having different letters are significantly (p < 0.05) different from each other.

Chromium

Table 16 showed chromium concentration of water taken from different areas of Darra Adam Khel having coal mines. Chromium of water samples utilized for drinking wereB_1(3.96mg/l), T_1(3.36mg/l) from Bazi Khel area, B_2(3.36mg/l), T_2(3.53mg/l) from German Kaly area, B_3(2.80mg/l), T_3(1.13mg/l) from Qasam Khel area, B_4(5.16mg/l), T_4(4.56mg/l) from Suni Khel area, B_5(2.70mg/l), T_5(4.36mg/l) from Feroz Khan Mela area, B_6(5.13mg/l), T_6(8.16mg/l) from Toor Khel area, B_7(5.06mg/l), T_7(3.76mg/l) from Akhoor Waal area. Highest mean value for chromium concentration 8.16mg/l was noted in Toor Khel Tube well water, while the lowest mean value 1.13mg/l was noted in Qasam Khel tube well water.

Mean values of chromium concentration in drinking water samples from Bore water and Tube well water were 4.02mg/l and 4.12mg/l respectively. Safe level for chromium is 0.5mg/ l so all the sample were contaminated.

Statistical analysis showed that the area and interaction had significant (P<0.05) effect on chromium of collected samples, while source had no effect. Chromium normally deposits in plants, rocks, soil, animals and volcanic dust (Nasir *et al.* 2012).

It goes in to ground water from old mining activates, runoff. Also chromium corrosion from pipes, steel and from natural deposits (Cefalu and Hu, 2009).

It is classify as a cancer causing metal by international agency for cancer research (IARC, 2016). Chromium was noted in range of 0.005 – 0.978mg/l by Wei *et al.* (2018) while studying effects of mining on heavy metals.

Total Coliform

Microbial count for total coliform was noted in bore and tube well water taken from different areas of Darra Adam Khel having coal mines utilized for drinking were in the range of 0 MPN/ 100 ml to 210

MPN/ 100 ml. From two sources 14 samples was observed out of which 7 samples were affected above allowable limit. Highest mean value for total coliform count 210 was noted in Feroz Khan Mela tube well water, while lowest mean value 0was noted in almost 7 samples from both sources.

Statistical analysis showed that the area, sources and interaction had significant ($P<0.05$) effect on total coliform of collected samples (Table 17). These results were out of limit which is 0 MPN/100ml defined by PSQCA and WHO, due to less effective water purification system raw water being contaminated by the sewerage system as the key reason of contamination is the mixing of fresh water with sewerage water. Huge possibility of microorganism's species in environment which has coal mines as almost no interference for them (Roohi *et al.* 2014).

Our results are in accordance same like work done by (Sanderson *et al.* 2005). Both surface and ground get polluted by chemical and biological contamination which comes from varied source and due to alternation in nearby environment (Gieldrei, 1990). Farooq *et al.* (2008) noted total coliform 1.1 to 23.0 MPN /100ml in Rawalpindi.

Conclusion

Drinking water samples collected from seven locations and two sources in Darra Adam Khel was analyzed for its physiochemical and microbial load of total coliform and compared with Pakistan Standard Institution (PSI) and World Health Organization (WHO) recommended level.

It was concluded from this research that drinking water in the selected area were carrying physiochemical contaminations for calcium in three location, some heavy metals (lead and chromium) were found elevated than recommended level of World Health Organization and also about fifty percent of water samples were contaminated with microorganisms making water unfit for drinking. While the rest of quality parameters were in safe range.

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