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Research Article

Evaluation of Drinking Water Quality in Rural Areas of Khyber Pakhtunkhwa Pakistan: A Case Study of Upper Dir and Barawal Districts

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Abstract

Physicochemical studies were carried out during September to October 2013 in order to estimate the quality of drinking water from various resources in different locations of Upper Dir and District Barawal. The result of water quality parameters were analyzed as per USP (United State Pharmacopeia), WHO and Pakistan Council of Research in water Resources (PCRWR) methods and defined standards. Majority of drinking water samples are free from contamination and the water is suitable for human and household consumption. However, there are evidences of contaminants in a few samples which indicate that the drinking water in the study area is facing strain which could change the quality of the water in the near future.

Keywords: *Drinking Water Quality, Physicochemical studies etc.*

Introduction

It is very necessary to check quality of drinking water at regular intervals, because due to its contamination, human population suffers from various water borne diseases (Basavaraja Simpi *et al.*2011). Only 1% part of all water on earth is available on land for drinking and human consumption, agriculture, household power generation, industrial consummation, shipping and waste disposal (Lui *et al.*, 2000). Being as universal solvent water can dissolve many organic or inorganic compound. Therefore water is hardly found in clean shape. Poor water quality is responsible for the death of people. An estimated 5 million children die every year in the developing countries (Huang and Xia, 2001). If all the physicochemical and biological parameters are in most favorable condition the balance between these is maintained (Pratiksha Tambekar *et al*, 2012). According to GWSSAR report, Asia 20%, sub Saharan Africa 42% and 2.2 billion people of the globe need safe drinking water for people. In Pakistan, 66% of the drinking water is obtained through pipes networks and local hand pumps. About 30% of waterborne diseases and 40% of people die due to unavailability of clean and fresh safe water for drinking. Diarrhea and cholera, causes majority of deaths in infants and new borne babies of Pakistan. Every fifth person is suffered from diseases caused by polluted water. According to GWSSAR reports, more than three million Pakistanis are suffered from this diseases caused by poor quality of water each year and out of which 0.1 million die (Bhatti *et al*, 2006). Contaminated water is one of the major risks to public health in Pakistan. Pakistan numbers 80, out of 122 nations of the globe, on the basis of poor water quality.

In Pakistan, drinking water supplies are mainly use from surface water sources or with the underground aquifers. Regarding 70% of the whole drinking water provisions are obtained from underground aquifers. Drinking water quality in some areas of Pakistan is also not in unity to the WHO/Pakistan guidelines. In three districts namely Thatta, Badin, and Thar, are southern Sind Pakistan, is very poor water quality was found accountable for gastroenteritis, diarrhea and cholera, kidney, and skin diseases (Memon *et al.*, 2011). Poor institutional planning, lack of well prepared laboratories and the absence of a legal agency for drinking-water quality issues have forced the situation (Aziz, 2005).

Currently, Pakistan has no national drinking water quality standards and WHO guidelines for drinking water (WHO, 1996). The statistics of water are variables but according to WHO study about 36% of urban and 65% of rural Indian's have no reach to clean

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drinking water (WHO, 2009). According to the report of UNICEF 2010, in the world 884 million people of the developing country use poor drinking water sources in 2010 and it estimates that in 2015 about 672 million people will still using unsafe drinking water sources. Khalid *et al* (2011 worked for the qualitative analysis of drinking water samples of different area in Abbottabad, Pakistan. The results showed sources of water-borne diseases, which are very common among the people in the study area. Khan *et al* (2012 reviewed the physic-chemical estimation of the drinking water sources from Kohat, Khyber Pakhtunkhwa. Among 54 water samples from various sources, wells and tanks were highly contaminated with pollution while tube wells were found to be the most suitable source for drinking water and household consumption. Polluted drinking water causes many diseases as diarrhea, vomiting, gastroenteritis, dysentery, kidney problems etc. found in Thatta, Badin and Thar districts of southern Sindh, Pakistan (Memon*et al*., 2011). Improper disposal of solid waste, sewage water, and too much use of fertilizers were the main reasons of water contamination (Khan *et al*., 2012). In a study to determine the effects of polluted water used for irrigation on ground water quality and causing health problems in Jamber, district Qasur (Pakistan) results indicate that use of polluted water enhance the value of conductivity, total dissolved solids (TDS) and sodium absorption ratio etc. in ground water and exceeds the national standards (Ashraf *et al*., 2010). It is proved that there is a keen relationship between people income and literacy of mother to water quality and health issue. More literate mothers and high income groups have the ability to prevent waterborne diseases to their family (Kausar *et al*., 2009). Comparison of the physicochemical parameters of the water sample from Tumkur district Karnataka India by B. Nirmal *et al* 2013, with International standard limits showed that the groundwater is highly contaminated and account for health hazards for human use. As per analytical report of 39 drinking water samples of Mardan Khyber Pakhtunkwa by Khan *et al* 2013 showed Electric Conductivity 38 %, taste 25 %, hardness 20 % and TDS 15 %, which were not in the acceptable limits for drinking specified by the World Health Organization (WHO) and Pakistan. Geetu Goel and Surinderjit Kaur 2012 studied chemical contamination and cause of water pollution due to household laundry detergents were conducted to study the chemical payment of laundry detergents to waste water and environmental pollution. The study showed that with the use of powder detergents, there was increase in the rank of pH, TDS, chlorides, sulfate, carbonate and bicarbonate in clean usable water, whereas very small change was found in all the above chemical qualities with the use of liquid detergents and soup. Haydar *et al* 2009 investigated drinking water quality in Inner-city areas of Lahore Pakistan. The present study deals with physicochemical properties of drinking water of selected areas of district upper Dir and Barawal. The tests include acidity, alkalinity, pH, chlorides, turbidity, TDS, salinity, color, odor, taste, Oxidizable substances, nitrates and conductivity. Alkalinity is quantity of ions in water that will react to neutralize hydrogen ions. Constituents of alkalinity in natural water systems include carbonates and bicarbonates at large. It can be used to estimate temporary hardness.If water that is high in bicarbonates is used for irrigation then this could have longer term effects on soil fertility. High concentration of chlorides in natural water is due to organic waste and animal and industrial effluents and is regarded as indicator of pollution. For drinking water around 200 – 250 mg/l chloride is considered permissible and 600 mg/l chloride is considered excessive. Sulfates occur in appreciable quantities in all natural waters. Sulfates bring hardness in water. In ground water nitrates may enter through leaching from soil. The temperature of surface waters governs to a large extent the biological species present and their rates of activity. Turbidity may be caused by very fine colloids from clays or particulate organic matter or even caused by algal growth. It may also be caused by solids which are carried or suspended in the water. It is therefore a useful way to measure quality. Insoluble particles of soil organic microbes and other material impede the passage of light to water by scattering and absorbing the rays (Hammer, 1986). Around 15 FTU water looks fairly clear but is slightly cloudy. At around 70 FTU's water looks cloudy. It is usually caused by suspended particles of sand, silt and clay which are not harmful in low amounts. However, higher turbidity levels are often associated with higher levels of viruses, parasites and some bacteria because they can sometimes attach themselves to the dirt in the water. Turbidity should be less than 0.5 Nephelometric Turbidity Units (NTU) and pH should be less than 8 for effective disinfection (WHO 2004). If it is greater than 5 NTU, sedimentation and/or filtration should be undertaken to reduce the levels. The graph in figure shows how microbiological contamination (indicated by E. coli) can increase with turbidity (CAWST, 2009). A convenient way to estimate the total amount of dissolved salts in water is to measure its electrical conductivity. However a conductivity measurement can't distinguish between salts. Dissolved ions like sodium and chloride tend to have high conductivities than other ions like calcium, magnesium and sulphate. Therefore water with a higher proportion of sodium and chloride tends to have higher conductivity than water with the same amount of salt but a higher proportion of calcium, magnesium and sulphates. It is originally conceived as a measure of the mass of dissolved salts in a given mass of solution. Generally conductivity values of under 3500 μS/cm are acceptable for drinking water. Salinity is really made up mostly by the concentrations of sodium calcium, magnesium, potassium, chloride, sulphate and bicarbonates. Phosphates and nitrates may also make up a small part of the salinity. Salinity is sometimes measured as parts per million or mg/l. This is usually called Total Dissolved Salts (TDS). If there is a relative high proportion of sodium and chloride in your water then take the conductivity value in µS/cm and multiply by 0.55 to get an approximate figure for TDS in mg/l. Otherwise use a factor of 0.67. Estimating TDS from conductivity provides an approximation only.

Materials and Methods

The study is conducted in Shaheed Benazir Bhutto University Sheringal District Upper Dir which is located at 35^0 latitude, 72^0 longitude and elevation of 4544 ft in KPK Pakistan. Dir Upper borders Afghanistan to the west, Chitral and Swat districts to the north and east respectively, and Lower Dir to the south. Sheringal valley consists of 07 union councils, Sheringal, Ganshal, Sawni, Dogdara, Gwaldi, Patrak and Kalkot. According to the population census report of 1998 the total population of this area is 77115 individuals and average population per square mile is 120. The river Panjkora is fed by small streams/ mullahs through various valleys (Saddozai, 1995). A total of 28 water samples were collected from, spring, house wells and river of the selected location from Upper Dir and Barawal districts. All samples were given respective code numbers for traceability, collected in clear clean and dry sterile polyethylene sealed bottles and sample size was maximum 01 liter. The collection of samples left no air bubble during filling of bottles. Tests for temperature, odor and taste were performed at the field site, while for other tests the samples were taken to the Chemistry lab (Figure 7a, 7b) and Environmental Science lab (Figure 7c), of Shaheed Benazir Bhutto University Sheringal Upper Dir KPK, immediately without the addition of preservatives or any other additives; however ice-packs were included into the box containing sample bottles. Analysis was carried out as per USP/ IP and BP standard methods. Information about areas longitude, latitude and elevation were determined by GPS according to the procedure mentioned by Khalid *et al*, 2011. Calibration of instruments and expiry dates of all chemicals were checked before proceeding for analysis. Various calibrated instruments were used that include **Jenco 3173 USA**

Conductivity/ Salinity meter, **Lovibond senso direct pH 110 USA** pH meter, **HANNA HI 93703 microprocessor Germany** Turbidimeter, **Mammert, Germany** water bath etc. High quality standard chemicals from Scharlau, Merck and BDH were utilized that included Sulfuric acid, potassium permanganate, Nitric acid, Silver nitrate, Bromothymol, Sodium hydroxide, Methyl red, Hydrochloric acid, Barium chloride, and diphenylamine etc. For determination of Alkalinity, 10 ml water sample is titrated with standard solution, while using 0.01ml Bromothymol as indicator. When the color of sample doesn't change to blue is the indication of end point. WHO/Pakistan standard value for total alkalinity in drinking water is 500ppm. Chloride can be tasted at around 500 to 1000 mg/l. 10 ml water sample is added with 1 ml nitric acid (2 M nitric acid) solution used as indicator for 15 minutes. No change of color after 15 minutes indicates no or less chloride in the sample. For Sulphates, 10 ml of water sample is added with 0.1 hydrochloric acid, 2 M Hydrochloric acid and 0.1ml Barium chloride weight/volume 10%. Appearance of solution does not change for one hour. Change of appearance within one hour is indicative of excess of sulfates or hardness. For determination of Acidity, 10 ml water sample is titrated with standard solution 0.01ml methyl red using as an indicator. The color should not be changed to red, the sample will be alkaline. If color is changed to red, it shows acidity. For Oxidizable substances, 100 ml sample is mixed with 10 ml Sulfuric acid and 0.02ml potassium permanganate then boiled for 5 minutes the solution remained faintly pink. If Oxidizable substances are intense pink, it shows the presence of excess of Oxidizable substances. For Nitrates determination, 10 ml water sample is titrated with 0.4 ml of a 10% weight/volume solution Potassium Chloride and 0.1 ml Diphenylamine. Then 5 ml Sulfuric acid drop wise is added with shaking. The tube is transferred to the water bath at 50^{0}C for 15 minutes. Any blue color in sample is not more intense than standard. Intense blue color indicates more dissolved nitrates. Temperature of sample is measured at the sample point immediately after the collection by mercury centigrade thermometer. Lower the pH value higher is the corrosive nature of water. pH is positively correlated with electrical conductance and total alkalinity (Guptaa 2009). pH of sample was measured by the pH meter. Turbidity of sample was measured by the turbidity meter. The range is from 0 to 400 FTU. For drinking water turbidity should be around 3 –5 FTU's or lower. Conductivity of the sample was measured by conductivity meter. Salinity of the sample is measured by Salinity meter.

Results and Discussion

28 samples (14 each from 05 union councils of district Dir Upper and Barawal districts respectively) were analyzed. 04 sampling sources of spring, Storage tank, House well and River or Stream, were selected and given various codes of S, T, W and R respectively. 12 samples from spring, 06 sample from river, 06 from house well while 4 samples from storage tank were evaluated. Dir and Patrak were highly populated while Shahoor and Shahikot were high in altitude (Table 1). Samples from Barawal tank and Qulandi river failed the clarity test which indicated some chemical instability or/and bio-burden (Table 2). Temperature of 26.6^0 C was observed in Qulandi Tank water while 24.5^{0}C was recorded for Shahoor stream water. pH of 6.55 was recorded for Sawni House well water while 8.01 for Patrak House well water, which were within the standard limits by WHO and Pakistan Council of Research in water Resources (PCRWR) i.e. 6.5-8.5. The highest desirable pH level according to PCRWR is 7-8.5. Low pH values of Sawni river and Barawal well may have higher corrosiveness. The recorded electrical conductivity was 91.0 µS/cm for Patrak house well and

Table1: Data of sample locations

Location	Sampling Source	Description of Sample Source	Code	Elevation (ft)	North	East	Population
District Upper Dir							
Patrak	Spring uncovered	Uncovered	S1	4909	35^0-20.300	72^0-03.228	200
	Stream	Patrak-Gwaldi	R1	5103	35^0-20.911	72^0-03.872	6000
	House Well	House well 30 ft	W1	4987	35^0-20.559	72^0-03.228	50
Dogdara	Spring	Uncovered	S2	5118	35^0-18.638	72^0-00.136	150
	Stream river	Panjkora	R2	5009	35^0-18.603	71^0-59.992	1000
Biargal	Spring	Covered	S3	4544	35^0-16.197	72^0-00.173	1200
Sheringal	Spring	Covered	S4	4547	35^0-16.420	72^0-00.52	600
Shahoor	Spring	Uncovered	S5	5230	35^0-15.938	72^0-00.845	180
	Stream river	Panjkora	R3	4439	35^0-16.008	72^0-00.406	200
	House Well	House well 20 ft	W2	5269	35^0-16.079	72^0-00.970	120
Sawni	Spring	Uncovered	S6	4578	35^0-13.512	71^0-59.355	500
	River	Panjkora	R4	4303	35^0-14.246	71^0-59.810	600
Doru	Spring	Uncovered	S7	4825	35^0-13.973	72^0-00.134	350
Samang	House Well	House well 25 ft	W3	4950	35^0-59.845	71^0-16.076	400
District Barawal							
Darikand	Spring	Covered	S8	4746	35^0-05.251	71^0-45.488	600
	Well	House well 84 ft	W4	4727	35^0-05.155	71^0-45.488	500
	Tank	Storage Tank	T1	4746	35^0-05.251	71^0-45.488	1700
Shahikot	Spring	Uncovered	S9	5355	35^0-05.041	71^0-42.098	130
	River	Panjkora	R5	5310	35^0-05.084	71^0-42.024	300
Barawal	Tank	Storage Tank	T2	4849	35^0-05.938	71^0-45.975	1800
	Spring	Uncovered	S10	4731	35^0-05.359	71^0-45.359	600
	House Well	House well	W5	4830	35^0-05.411	71^0-44.724	4000
Dir urban	Spring	Covered	S11	4580	35^0-12.712	71^0-52.703	7000
	Tank	Storage Tank	T3	4665	35^0-12.526	71^0-52.562	5000
	Well	House well	W6	4665	35^0-12.524	71^0-52.562	450
Qulandi	Spring	Uncovered	S12	4710	35^0-12.937	71^0-52.33	100
	River	Panjkora	R6	4685	35^0-12.937	71^0-52.33	0
	Tank	Storage Tank	T4	4708	35^0-12.986	71^0-52.352	400

Table 2: Analytical data of selected 28 samples

Area	Source	Code	Color	Odor	Taste	Temp (°C)	pH	Turbidity (FTU)	Salinity (ppm)	Conductivity (µS/cm)	Approx. TDS (ppm)	Sulphates	Alkalinity	Acidity	Chlorides	Oxidizable substances	Nitrates
Patrak	Spring	S1	Clear	Nil	Nil	24.6	7.40	0.974	46.7	93.5	51.425	M	M	M	M	M	M
	River	R1	Clear	Nil	Nil	24.8	7.30	1.10	184	376	190.3	M	M	M	M	H	M
	Well	W1	Clear	Nil	Nil	24.6	8.01	1.33	45.5	91.00	50.05	H	M	M	H	M	M
Dogdara	Spring	S2	Clear	Nil	Nil	24.7	7.73	0.25	148	296	162.8	M	M	M	H	M	M
	River	R2	Clear	Nil	Nil	24.6	7.80	1.36	66.8	121.8	66.99	M	M	M	H	M	M

Dir urban			Barawal			Shahikot		Darikand			Samang	Doru	Sawni		Shahoor			Sheringal	Biargal
Well	Tank	Spring	Well	Spring	Tank	River	Spring	Tank	Well 84 ft	Spring	Well 25 ft	Spring	River	Spring	Well 20 ft	Stream	Spring	spring	Spring
W6	T3	S11	W5	S10	T2	R5	S9	T1	W4	S8	W3	S7	R4	S6	W2	R3	S5	S4	S3
Clear	Clear	Clear	Clear	Clear	Not clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
25.9	25.9	25.9	26.2	26.2	26.3	26.2	26	25.9	26	25.9	25.3	25.3	24.9	24.7	24.6	24.5	24.6	24.5	25.3
7.3	7.45	7.1	6.85	7.05	7.39	7.60	7.25	7.38	7.06	7.12	7.1	7.7	6.55	7.41	7.47	7.63	7.43	7.45	7.38
2.29	1.85	1.58	0.6575	0.423	3.405	1.146	1.063	0.4175	0.74	0.715	1.79	0.612	2.65	0.295	0.65	1.98	0.62	2.9	1.493
196	196	312	284	384	100	155	284	157	214	188	269	156	56	227	240	55	189	233	328
393	114	625	569	769	200	310	363	314	427	376	539	312	112	453	480	110	375	461	658
216.15	62.7	343.75	312.95	422.95	110	170.5	199.65	172.7	234.85	206.8	296.45	171.6	61.6	249.5	264	60.5	206.25	253.55	361.9
M	M	M	M	L	M	M	M	M	M	M	M	M	M	M	M	M	H	M	M
M	M	L	M	M	L	M	M	M	M	M	M	M	M	H	M	M	M	M	M
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
L	M	M	L	L	M	M	M	M	L	L	M	M	M	H	M	M	H	M	M
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
M	M	M	M	M	M	M	M	M	M	H	M	M	M	M	M	M	M	M	M

Qulandi	Spring	S12	Clear	Nil	Nil	26.3	7.47	1.22	180	360	198	M	M	M	L	M	H
	River	R6	Not clear	Nil	Nil	26.5	7.75	3.84	65.8	131.9	72.545	M	M	M	M	M	H
	Tank	T4	Clear	Nil	Nil	26.6	7.85	1.776	48.9	97.3	53.515	L	M	M	M	M	M

769 µS/cm for Barawal spring. USP 23 (As of 11/96), the limit for conductivity is 4.7-5.8 µS/cm (depending on pH). The conductivity in 09 water samples was more than the WHO/ Pakistan permissible limits i.e. 400 µS/cm, which is indicative for various ailments and diseases in the local population. Turbidity was in the range of 0.25 FTU to 3.84 FTU in Dogdara spring and Qulandi river respectively). A close relationship of turbidity and presence of E-coli can be made from this study (Figure 6). Salinity of 45.5 ppm and 384 ppm were observed in Patrak house well and Barawal spring, respectively. The most interesting aspect of this study is the observation of a few interrelationships of some parameters. Increase in conductivity has resulted an increase in Total dissolved solids (Figure-1).

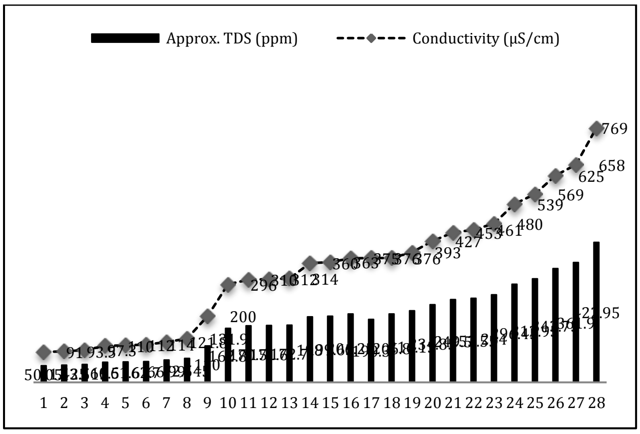

Figure 1: Chart representing close relationship of conductivity with TDS

However, no relationship existed in conductivity and pH (Figure-2). Salinity was also not uniformly proportional at different temperatures (Figure-3). Salinity, TDS and conductivity showed an extremely interdependent close relationship (Figure-4). Salinity was also coincided with altitude and it was observed that at higher altitude the salinity is higher (Figure-5). Most samples from various sources were within the specified limits as set by WHO/ USP/IP/ Pakistan. 12 water samples (42.8%) showed higher concentration in alkalinity, chlorides, sulphates, Oxidizable substances and nitrates qualitatively, while 10 samples (35.7%) showed lower concentration in alkalinity, sulphates and chlorides. The overall variation in results is indicative of higher stress on water for drinking purpose. Further Microbial and environmental studies are required to assess water quality for drinking purpose by the rural population. However, all the 28 water samples passed the tests for acidity, pH, odor and taste.

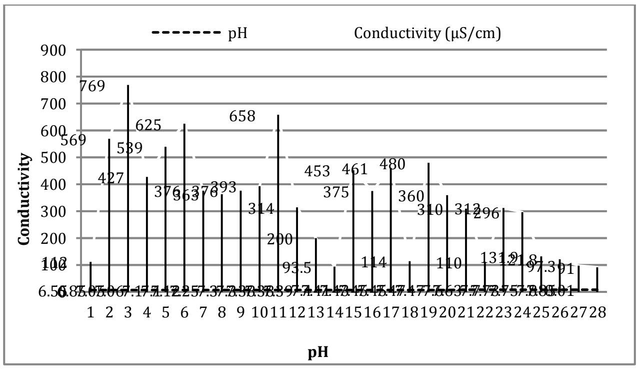

Figure 2: Comparative chart showing conductivity at various pH

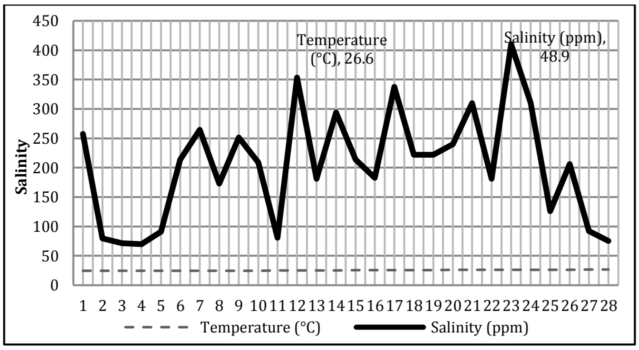

Figure 3: Chart representing observed temperature and salinity

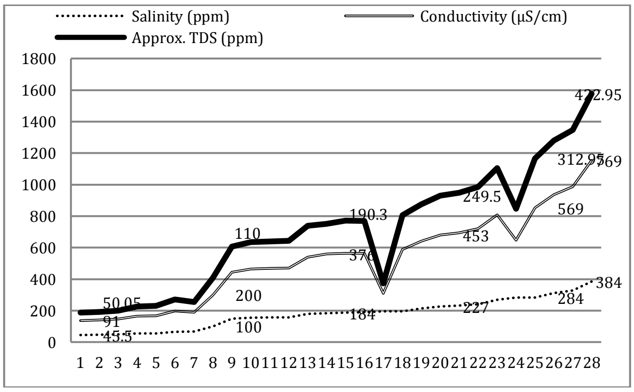

Figure 4: Chart indicating close relationship of TDS, conductivity & salinity

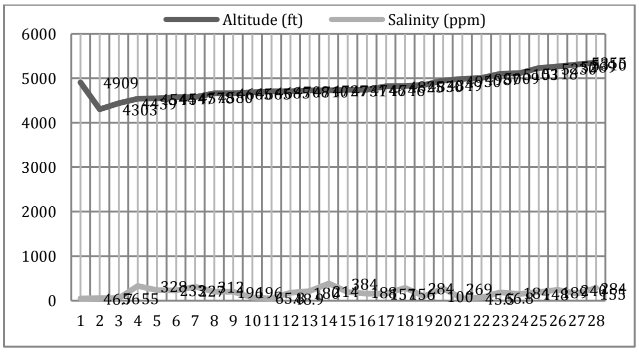

Figure 5: Chart representing close relationship of high altitude with salinity

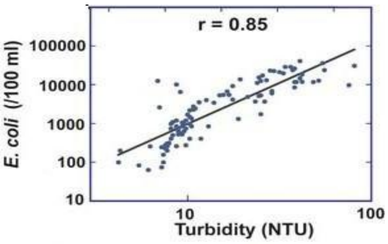

Figure 6: Relationship between level of turbidity and presence of *E. coli* in source water


7a **7b**

7c

Figure 7: Snapshots and images

Conclusion

It is concluded from the study that spring and well water is considered to be the safe one as compared to river water. Water samples from Patrak and Shahoor River and Sheringal wells are under strain due to overpopulation, unhygienic public activities and bio-burden. The most prevalent diseases are diarrhea, dysentery, warm infestation, skin diseases, gall and renal stones along with various ulcers. According to Mr. Ata Husain, a medical technician working in Sheringal BHU, water borne diseases are common in the area. No qualified medical doctor is available for population of Dir-Kohistan. Access to DHQ hospital in Dir urban is extremely difficult due to minted road. Mother and child care, and population welfare are the core issues to be addressed. Recent country wide devastating flood in 2010 has also impacted the surface and ground water channel. Uncovered and unprotected springs and wells are direct threats for water pollution. Garbage and latrines are open; while the waste water is in direct contact with river Panjkora. Epilepsy is common in Sheringal and every second person is psychologically depressed. We have found variation in almost all physical and chemical parameters in the drinking water samples that may compromise the health status of rural population of Dir and Barawal districts, in the near future. Therefore, it is concluded that clean and safe water supply should be ensured for rural areas as top priority by the government and non-government agencies in Pakistan.

Recommendations

Based on the drinking water quality and data generated during the experiment, the following specific recommendations are made. Based on the water quality and survey data generated during the study, it is recommended that:

- The points of clean water must be recognized in various locations and should be communicated to the peoples, to make clean water available to the masses,
- Regular cleaning and disinfection of the domestic water is needed by using disinfecting agents,
- Water borne diseases are more in areas where the people are poor and have poor living standards. So the diseases are an extra burden on the pocket of the poor peoples. Therefore water quality is affecting the socio-economic conditions of the peoples of the project area,
- The problem of cross contaminations should be minimized by restricting pipelines passage along spring or stream,
- Septic tanks should be made away from the wells and the wells should be cemented to stop any accidental leakage of waste in the wells water,
- Proper monitoring of drinking water quality is needed. Inspection teams should be made to monitor the water quality effectively,
- Government should established water filtration plants at the village or union council level to make available clean water to the peoples,
- To protect the open well from contamination, the wells should be covered and raised above the ground,
- Awareness is needed to prevent the unwanted activities like servicing vehicles with faucet water

and watering gardens and lawns unnecessarily to prevent waste water production,

- Seminars and workshops should be frequently arranged to publicize the findings of the water quality analysis,
- Research should be promoted to develop low cost treatment technologies,
- Water filtration tablets, water purifying kits, house filters and boiling methods should be used to purify water,
- Regular monitoring of the responsible department is needed to ensure the clean water availability to peoples by checking the water quality in their own certified labs

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