EUROPEAN ACADEMIC RESEARCH
Vol. II, Issue 1/ April 2014

Impact Factor: 3.1 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

# Hand Pumps' Water Quality Analysis for Drinking and Irrigation Purposes at District Dir Lower, Khyber Pakhtunkhwa Pakistan

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**Abstract:**

*The present preliminary study was undertaken to evaluate the hand pumps' water quality in District Dir Lower, Khyber Pakhtunkhwa Pakistan, for drinking as well as irrigation purposes. A total of 11 water samples were collected from hand pumps at different places and were analyzed for various physico-chemical parameters. The results of evaluated parameters were compared against the standard guideline values suggested for drinking and irrigation purposes. The parameters studied were pH, electrical conductivity, total solids, total hardness, calcium hardness, magnesium hardness, alkalinity, total dissolved solids, total suspended solids, sodium, chlorides, nitrites, sulphate, potassium, carbonate and bicarbonate. The results showed that only electrical conductivity was deviating from the suggested permissible limits for two sampled sites while all other studied parameters, for all studied areas, were falling within World Health Organization suggested ranges. The chemical indices like Sodium Absorption Ratio, Sodium Percentage and Residual Sodium Carbonate classify the water quality as excellent for agricultural*

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*practices. To protect water quality, it should be assessed regularly. Agricultural run offs and domestic wastes should be treated properly before disposing off and waste materials should be dumped to suitable sites.*

**Key words**: Chemical parameters, Permissible limits, Physical parameters, WHO.

## 1. Introduction

Water is the basic need of life but tragically its quality is continuously deteriorating due to different anthropogenic activities (Agarwal 2002). Surface and ground water quality degradation is the burning issue echoing on the horizon of environment research. The degree of human dependency on water and scarcity of usable water (0.002% of total water) renders its conservation on priority basis (Yousaf *et al.* 2013). Water pollution, related health threats and aquatic biodiversity effects are clear like broad day light. Groundwater is an important natural resource, may be renewable or nonrenewable depending upon its use and consumption. Approximately one third of the world's population is using groundwater sources for drinking purpose (Nickson *et al.* 2005).

Groundwater is the principal source of water supply and presently it is the most plentifully consumed (more than 70%) valuable natural resource for various human activities (Prasad and Narayana 2004). Unfortunately groundwater contains various types of pollutants and several other substances. Concentration of these substances are useful for human body and health but in a specific amount. Excess of these substances impair the water quality and render it unfit for human use. Most of the diseases are water borne in nature. According to "community health study" drinking of poor water quality is responsible for 50% of all the reported cases of diseases. In Pakistan 40% mortalities are due to drinking of poor quality of

water (Chhatwal 1990).

On account of safe and uncontaminated ground water scarcity, this issue remains one of the most debatable problems since the start of this century. Still this sector of study is appealing, so research is being conducted all over the world and almost all over Pakistan. Water quality assessment has also been carried out in different districts of Khyber Pakhtunkhwa province, such as; District Nowshehra (Yousaf *et al.* 2013), District Kohat (Khan *et al.* 2013), District Charsada (Khan *et al.* 2012), District Mardan (Saeed *et al.* 2012), District Buner (Khan *et al.* 2012) and District Peshawar (Khan *et al.* 2005). Similarly research has also been carried out on various rivers of the province but no updated data appears concerning ground water quality of District Dir Lower. Therefore the current work was carried out in order to assess hand pumps' water quality at District Dir Lower.

The water quality is generally assessed by comparing its physico-chemical parameters against the suggested permissible limits (Burston *et al.,* 1993). Therefore during the study different physico-chemical parameters were evaluated for analyzing the water quality of hand pumps in the study area. These parameters were pH, electrical conductivity, total solids, total hardness, calcium hardness, magnesium hardness, alkalinity, total dissolved solids, total suspended solids, sodium, chlorides, nitrites, sulphate, potassium, carbonate and bicarbonate. Results for these parameters were compared with the suggested permissible ranges of World Health Organization for human consumption.

## 2. Materials and Methods

### 2.1. Study Area

District Dir Lower is located with Latitudes and Longitudes of 71°, 31′ to 72°, 14′ East and 34°, 37′ to 35°, 07′ North respectively. It is approximately 2700 feet above mean sea level

(Ali *et al.,* 2008). An annual rain fall of 1468.8 mm and 253.7 mm during December and March respectively is common. District Dir is bounded by District Chitral (North), by Bajaur and Afghanistan (West), by District Malakand (South) and by District Swat (East) (Khan *et al.* 2010). River Panjkora is the key river in District Dir that originates from Kohistan, District Dir (Upper) and flow southward dividing District Dir Upper and Lower into two halves. River Panjkora joins River Swat at Sharbatti Pull (behind Totakan, District Malakand). Fig. 1 shows sampling sites in the study area.

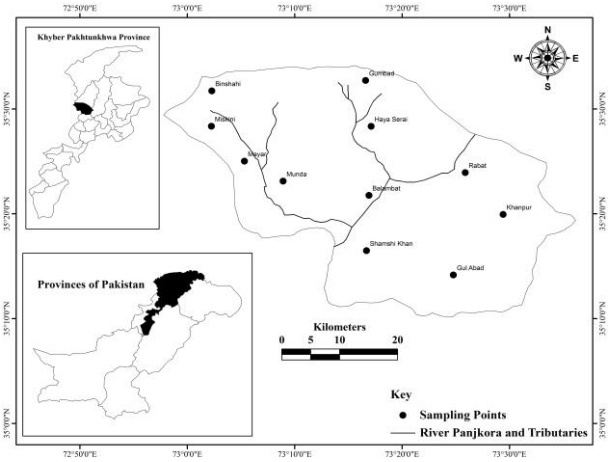


**Fig. 1: Map showing District Dir Lower and the sampling sites**

## 2.2. Water Sampling and Analysis

The collection of Water samples was carried out by using polythene bottles. These bottles were first washed with tap water and were then rinsed using double deionized water. A total of eleven samples were collected from various places within the study area. The samples were tested for pH and conductivity on the spot and were transported to the laboratory for further analysis.

The pH was found out with portable pH meter (Natner, UK made). The conventional methods referred by American Public Health Association [APHA/AWWA, 1998] were followed

for determining total alkalinity (T.A), total suspended solids (TSS), total dissolved solids (TDS), total hardness (T.H), magnesium hardness ($Mg^{+2}$), calcium hardness ($Ca^{+2}$), chlorides ($Cl_2$), and sulphate ($SO_4$) contents. For finding out Nitrate ($NO_2$), Sodium ($Na^+$), Potassium ($K^+$), Carbonate ($CO3^{-2}$) and bicarbonate ($HCO_3^-$) methods of Yousaf et al. [2013] was followed. The other parameters i.e., color; odor, taste and turbidity were observed organolaptically.

### 2.3. Statistical Calculation

Mean, Standard deviation, Pearson Correlation Coefficient and Percentages were found out using Microsoft Excel 2010. Map for the study area was prepared using Arc GIS 9.3 platform. The Agricultural indices, Sodium Absorption Ratio, Sodium Percentage and Residual Sodium Carbonate were calculated following the methodology of Kaur and Singh [2011].

## 3. Results and Discussion

The results for studied water parameters showed variation between different ranges. The results showed that 90.909% water samples were colorless, odourless, tasteless and clear. The observed mean electric conductivity was 1175.636µs/cm for all sampling sites, which falls within the suggested permissible limit but yet it deviates in two of the locations and exceeds suggested permissible limit. The observed mean pH was 7.254 for all locations, showing that pH of the study was falling within the suggested permissible limits and has no distressing situation [WHO 2011].

The water quality parameters were observed and the results for most of the areas showed its fitness for human consumption. Most of water quality parameters were within the permissible limits when compared with suggested permissible limits of World Health Organization for human consumptions, rendering it fit for drinking purpose. The descriptions of some

Physico-chemical parameters for the sampled sites are given in Table 1.

Across all collected samples electrical conductivity ranged between 710 µs/ cm and 3170 µs/cm. The strongest correlations ($r > 0.5$, $p = 0.001$) with electrical conductivity included total suspended solids ($r = 0.933$), followed by nitrate ($r = 0.917$), pH ($r = 0.809$), sodium ($r = 0.718$), magnesium ($r = 0.517$) and potassium ($r = 0.507$).

**Table 1. Description of Physical and Chemical parameters of hand pumps' water samples**

| S. No | Location | Color | Odour | Taste | Turbidity | EC | pH | $CO_3$ | $HCO_3$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Munda | Colorless | Odourless | Tasteless | Clear | 821 | 7.3 | 250 | 30 |
| 2 | Balambat | Brownish | Smelly | Pungent | Turbid | 3170 | 7.9 | 260 | 20 |
| 3 | Rabat | Colorless | Odourless | Tasteless | Clear | 1770 | 7.7 | 180 | 70 |
| 4 | Haya Serai | Colorless | Odourless | Tasteless | Clear | 811 | 7.2 | 190 | 60 |
| 5 | Gul Abad | Colorless | Odourless | Tasteless | Clear | 1170 | 7.5 | 140 | 40 |
| 6 | Shamshi Khan | Colorless | Odourless | Tasteless | Clear | 1260 | 7.4 | 190 | 20 |
| 7 | Mayar | Colorless | Odourless | Tasteless | Clear | 800 | 7 | 260 | 50 |
| 8 | Binshahi | Colorless | Odourless | Tasteless | Clear | 825 | 7.1 | 230 | 20 |
| 9 | Khanpur | Colorless | Odourless | Tasteless | Clear | 710 | 6.8 | 290 | 30 |
| 10 | Miskini | Colorless | Odourless | Tasteless | Clear | 825 | 6.7 | 220 | 10 |
| 11 | Gumbad | Colorless | Odourless | Tasteless | Clear | 770 | 7.2 | 230 | 10 |

EC = Electrical Conductivity, $CO_3$ = Carbonate, $HCO_3$ = Bicarbonate

pH ranged from 6.7 to 7.9 across all sampling sites. The observed mean pH was 7.25, showing that pH of the study area has no alarming situation and fall within the suggested permissible limits. The strongest correlations ($r > 0.5$, $p = 0.001$) with pH included sodium ($r = 0.888$), total suspended solids ($r = 0.763$), nitrate ($r = 0.685$), total solids ($r = 0.643$), potassium ($r = 0.628$) and sulphate ($r = 0.529$).

The observed mean total solids was 951.82 $mgL^{-1}$, total dissolved solids was 899.27 $mgL^{-1}$, mean total suspended solids was 7.18 $mgL^{-1}$, total hardness was 524.09 $mgL^{-1}$, Calcium hardness was 285.91 $mgL^{-1}$, Magnesium hardness was 155.36 $mgL^{-1}$, alkalinity was 292.72 $mgL^{-1}$, Chloride was 114.45 $mgL^{-1}$, Nitrate was 0.736 $mgL^{-1}$, Sodium was 205.73 $mgL^{-1}$, Potassium

was 10.82 $mgL^{-1}$, carbonate was 221.82 $mgL^{-1}$ and bicarbonate was 32.73 $mgL^{-1}$. The results of Physico-chemical parameters are given in Table 2.

**Table 2. Physico-chemical parameters of Hand Pumps' water samples**

| Locations | TS | TDS | TSS | T.H | Ca | Mg | T.A | $Cl_2$ | $SO_4$ | $NO_2$ | Na | K |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Munda | 880 | 880 | 3 | 475 | 250 | 119 | 240 | 100 | 200 | 0.5 | 200 | 7.7 |
| Balambat | 1000 | 912 | 20 | 565 | 305 | 200 | 315 | 110 | 312 | 2 | 229 | 4.4 |
| Rabat | 1040 | 890 | 17 | 575 | 320 | 220 | 260 | 98 | 290 | 1.5 | 232 | 4.9 |
| Haya | | | | | | | | | | | | |
| Serai | 910 | 880 | 3 | 490 | 300 | 115 | 210 | 88 | 250 | 0.5 | 210 | 6.3 |
| Gul Abad | 975 | 910 | 5 | 475 | 270 | 120 | 280 | 93 | 273 | 0.5 | 217 | 7.5 |
| Shamshi | | | | | | | | | | | | |
| Khan | 950 | 890 | 8 | 510 | 270 | 135 | 210 | 90 | 250 | 0.5 | 205 | 5.7 |
| Mayar | 910 | 900 | 5 | 500 | 250 | 130 | 400 | 150 | 240 | 0.5 | 180 | 19.7 |
| Binshahi | 995 | 890 | 5 | 500 | 270 | 150 | 390 | 120 | 200 | 0.4 | 200 | 20.3 |
| Khanpur | 900 | 960 | 4 | 590 | 340 | 200 | 200 | 90 | 290 | 0.8 | 190 | 7.1 |
| Miskini | 910 | 900 | 5 | 500 | 250 | 150 | 415 | 170 | 210 | 0.5 | 190 | 18.3 |
| Gumbad | 1000 | 880 | 4 | 585 | 320 | 170 | 300 | 150 | 200 | 0.4 | 210 | 17.1 |
| S.D | 52.8 | 23.1 | 5.8 | 44.9 | 32.3 | 37.0 | 79.2 | 29.1 | 40.8 | 0.5 | 16.2 | 6.5 |
| WHO* | 1000 | 1000 | 5 | 500 | 250 | 150 | 500 | 250 | 250 | 0.5 | 250 | 75 |

*= WHO upper permissible limits for drinking water, S.D = Standard Deviation, TS= Total solids, TDS= Total dissolved solids, TSS=Total suspended solids, T.H= Total hardness, Ca=Calcium hardness, Mg=Magnesium hardness, T.A=Total alkalinity, $Cl_2$=Chloride, $SO_4$=Sulphate, $NO_2$=Nitrate, Na=Sodium and K=Potassium.

The suitability of the groundwater for irrigation purpose was determined on the basis of Sodium Absorption Ratio (SAR), Sodium Percentage (Na %) and Residual Sodium Carbonate (RSC) by following the methodology of Kaur and Singh [2011]. The results for SAR, Na% and RSC along with Sodium Hazard Classes (SHC) are given in Table 3.

SAR values were varying in the range of 11.56-14.72 for all sampling sites. All the sampled sites were falling in S2 (Good for Agriculture) class of Sodium Hazard Class (Wilcox 1995). Na % is expressed in epm. Sodium percentage values were falling in the range of 26.73% - 36.53% reflected that the water was good for agricultural purpose, as 20% - 40% comes under the category of good (Wilcox 1995).

**Table 3: Tube wells' water parameters for irrigation purpose**

| S. No | Location | SAR | SHC | Na % | RSC |
|---|---|---|---|---|---|
| 1 | Munda | 14.724 | S2 | 36.015 | -89 |
| 2 | Balambat | 14.411 | S2 | 31.609 | -225 |
| 3 | Rabat | 14.119 | S2 | 30.493 | -290 |
| 4 | Haya Serai | 14.578 | S2 | 34.262 | -165 |
| 5 | Gul Abad | 15.540 | S2 | 36.533 | -210 |
| 6 | Shamshi Khan | 14.406 | S2 | 34.221 | -195 |
| 7 | Mayar | 13.059 | S2 | 34.449 | -70 |
| 8 | Binshahi | 13.801 | S2 | 34.406 | -170 |
| 9 | Khanpur | 11.5630 | S2 | 26.740 | -220 |
| 10 | Miskini | 13.435 | S2 | 34.243 | -170 |
| 11 | Gumbad | 13.416 | S2 | 31.669 | -250 |

SAR= Sodium Absorption Ration, SHC= Sodium Hazard Class, Na %= Sodium Percentage, RSC= Residual Sodium Carbonate

RSC gives an account of calcium and magnesium in the water sample as compared to carbonate and bicarbonate ions. RSC value less than 1.25 indicates low hazard, whereas a value of 1.25- 2.5 indicates medium hazard and more than 2.5 indicates high hazard to crop growth. The results for RSC showed that all the sampling locations were less than 1.25. It means that the water can be employed for agricultural practices and is excellent for crop growth (Wilcox, 1995).

For the entire collected samples total dissolved solids ranged from 880 $mgL^{-1}$ to 960 $mgL^{-1}$. The observed mean total dissolved solid was 899.27 $mgL^{-1}$. The strongest correlations ($r > 0.5$, $p = 0.001$) with TDS was shown by sulphate ($r = 0.578$).

Total suspended solids, across all sampling sites, ranged from 3 $mgL^{-1}$ to 20 $mgL^{-1}$. The observed mean total suspended solid was 7.818 $mgL^{-1}$. The strongest correlations ($r > 0.5$, $p = 0.001$) with TSS was shown by nitrate ($r = 0.943$), followed by magnesium ($r = 0.689$) and sulphate ($r = 0.675$).

Total hardness ranged from 475 $mgL^{-1}$ to 590 $mgL^{-1}$. The observed mean Total Hardness was 524 $mgL^{-1}$. The strongest correlation ($r > 0.5$, $p = 0.001$) with Total hardness across all sampling sites was shown by magnesium ($r = 0.901$), calcium ($r = 0.86$) and nitrate ($r = 0.544$).

Across all sampling sites calcium ranged from 250 $mgL^{-1}$ to 340 $mgL^{-1}$. The observed mean Calcium Hardness was 285.91 $mgL^{-1}$. The strongest correlation ($r > 0.5$, $p = 0.001$) with calcium hardness across all sampling sites was shown by magnesium ($r = 0.734$), sulphate ($r = 0.532$) and total alkalinity ($r = 0.508$).

For all sampling sites magnesium ranged from 115 $mgL^{-1}$ to 220 $mgL^{-1}$. The observed mean Magnesium Hardness was 155.36 $mgL^{-1}$. The strongest correlations ($r > 0.5$, $p = 0.001$) with Total hardness across all sampling sites included magnesium ($r = 0.901$), followed by Calcium ($r = 0.863$) and nitrate ($r = 0.544$).

Total alkalinity ranged from 200 $mgL^{-1}$ to 415 $mgL^{-1}$ across all sampling sites. The observed mean Alkalinity was 292.73 $mgL^{-1}$. The highest correlation ($r > 0.5$, $p = 0.001$) with Total alkalinity was shown by chloride ($r = 0.838$) and potassium ($r = 0.823$).

Chloride ranged from 88 $mgL^{-1}$ to 170 $mgL^{-1}$ across all sampling sites. The observed mean Chloride was 182.272 $mgL^{-1}$. The strongest correlations ($r > 0.5$, $p = 0.001$) with chloride across all sampling sites included potassium ($r = 0.837$) and sulphate ($r = 0.531$).

Nitrite, across all sampling sites ranged from 0.4 $mgL^{-1}$ to 2 $mgL^{-1}$. The observed mean Nitrite was 0.736 $mgL^{-1}$. The strongest correlations ($r > 0.5$, $p = 0.001$) with Nitrite across all sampling sites included sodium ($r = 0.667$) and potassium ($r = 0.536$).

Sodium ranged from 180 $mgL^{-1}$ to 232 $mgL^{-1}$ across all sampling sites. The observed mean Sodium was 205.73 $mgL^{-1}$. The strongest correlation ($r > 0.5$, $p = 0.001$) with Sodium across all sampling sites was shown by potassium ($r = 0.623$).

Potassium ranged from 4.2 $mgL^{-1}$ to 20.3$mgL^{-1}$ across all sampling sites and observed mean Potassium was 10.82 $mgL^{-1}$. Carbonate ranged from 140 $mgL^{-1}$ to 290 $mgL^{-1}$ across all sampling sites and observed mean Carbonate was 221.82 $mgL^{-1}$.

Bicarbonate ranged from 10mgL$^{-1}$ to 70 mgL$^{-1}$ across all sampling sites and observed mean Bicarbonate was 32.73 mgL$^{-1}$. Potassium, Carbonate and Bicarbonate were not having any significant correlation with any of the parameters.

## 4. Conclusion

It can be concluded from the study that all the water samples, for all the sampled locations, were falling within the suggested permissible limits and can serve for drinking purpose. Only two samples were deviating for a single parameter, electrical conductivity, when compared against the WHO suggested permissible limit. The SAR, Na % and RSC analysis showed that the water is excellent for agriculture purpose and can be utilized for irrigation purposes. To protect the water quality from deterioration and maintain it usable quality, certain precautionary measures should be adopted such as; domestic wastes and agricultural run offs should be properly treated. Waste materials should be disposed off at proper places. Proper attention should be given to sanitation pipes and these should be carefully installed. Soil tests should be carried out before installing a hand pump. Awareness campaign and seminars should be carried out in order to educate the local masses about safety measures and importance of safe water quality.

**Disclosure**

None of the authors have any conflict of interest.

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