BACTERIOLOGICAL AND PHYSICO-CHEMICAL ANALYSIS OF DRINKING WATER FROM UNDERGROUND SOURCE IN DOMEL DISTRICT BANNU, KPK-PAKISTAN

Noor Zada Khan [1], Waheed Ullah [2], Zakir Ahmad[3], Abdullah[4],Imad Tariq[5], Fawad Inayat[6]

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[1]PhD Scholar at Department of Microbiology university of science & Technology Kohat
[2]Associate Professor at Department of Microbiology University of Science & Technology Kohat
[3]MPhil Scholar at Department of Biochemistry Abdul Wali Khan University Mardan
[4]Lecturer at the Institute of Health Sciences, Khyber Medical University
[5]Histopathology Technologist at the Agha Khan University Hospital, Karachi

Correspondence

[6]Fawad Inayat, MPhil Scholar at Department of Biochemistry, Abdul Wali Khan University Mardan, Pakistan
: +92-313-0918155
: fawad.313b@gmail.com
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ABSTRACT

OBJECTIVES

This study aims to assess the bacteriological and physico-chemical quality of drinking water sourced from underground pressure pumps in selected areas of Tehsil Domel, District Bannu, to determine its suitability for human consumption.

METHODOLOGY

Water samples were collected from forty underground pressure pumps across Tehsil Domel District Bannu following standard sampling protocols. The analysis included bacteriological parameters (total coliform, fecal coliform, E. coli, total plate count), physico-chemical characteristics (pH, electrical conductivity, salinity), pollution indicators (BOD, COD, TSS, TDS), and heavy metals (Cu, Zn, Pb, Cd). All analyses were conducted following WHO-approved standard methods.

RESULTS

Analysis revealed bacterial contamination in several villages, notably Bezan Khil, Bodin Khil, Bara Chashmi, and Masti khil, with bacterial colonies ranging from 398-566 colonies/ml. E. coli presence, elevated BOD, COD, TDS, and TSS levels exceeded WHO standards in these locations. While Cu and Zn levels remained within permissible limits, Pb and Cd concentrations exceeded WHO guidelines in several sites.

CONCLUSION

The drinking water from pressure pump sources in Tehsil Domel requires treatment before consumption to prevent waterborne diseases. Implementation of water quality management strategies is recommended to ensure a safe drinking water supply.

KEYWORDS: *Drinking Water, Pressure Pump source, Domel, Bannu, E. coli, Heavy metals*

INTRODUCTION

Water on the earth's surface is a valuable and common liquid. It is a dynamic element for the existence of life on the globe as water has ores which are very significant for human beings accompanied by further living creatures.[1] Water is used for miscellaneous purposes as it is a part of the principal nutrition item in our monotonous existence. Urbanization has developed from 31 to 34% in previous rare ages in Pakistan.[2] Availability of Potable drinking water condensed from 60 to 40% due to hasty augment in urbanization.[3] Water contamination has become a severe issue in Pakistan. The major causes of water pollution are generally the release of industrial waste materials, direct household, poor management of farm wastes and leakage from improperly maintained affected water tanks.[4] Many diseases are caused when toxic Arsenic is entered into the human body through drinking water.[5] Physico-chemical parameters for water quality include Total dissolved solids (TDS), Total suspended solids (TSS), Chemical oxygen demand (COD) and Biological oxygen demand (BOD).[6] The amount of organic pollutants are determined by COD which are found in waste and surface water.[7] Biological oxygen demand (BOD) is the sum of disbanded oxygen required by aerobic biological microorganisms in a body of water to measure the amount of organic pollution of water and the breakdown of organic material at a definite temperature over a precise period.[8] Many emerging countries of the world are facing either punitive scarcities of fresh water or the contamination of freely reachable water revenue.[1] A recent report by UNICEF stated that about 800 million

people in Asia and Africa are having life lacking access to fresh drinking water. As a result, various disorders in people have been caused by the lack of safe drinking water facilities.[9] Inappropriate drinking water quality is causing most diseases in Pakistan. The wide diversity of microbes is spreading waterborne diseases. The higher the level of faecal pollution more will be the risk of faecal-oral diseases when indicator bacteria (E. coli) is higher. 100 ml of drinking water should not have Fecal coliforms especially E. coli.[10] The primary objective of this research was to conduct a comprehensive physico-chemical and bacteriological analysis of underground potable water sources in Tehsil Domel, District Bannu. This study aimed to evaluate the water quality parameters to determine its suitability for human consumption and identify potential health risks associated with contamination.

METHODOLOGY

Forty drinking water samples were collected from underground pressure pumps across different locations in Tehsil Domel, District Bannu, following standard protocols described by APHA (2017).[11] Samples were collected in sterile 1L polyethene bottles, transported in ice boxes maintained at 4°C, and analyzed within 24 hours of collection. Water quality parameters including pH, electrical conductivity (EC), and salinity were measured in situ using calibrated portable meters (Hach HQ40d, USA). Total dissolved solids (TDS) and total suspended solids (TSS) were determined gravimetrically following Standard Methods 2540C and 2540D respectively.[12] Biological oxygen demand (BOD) was measured using the 5-day BOD test (Standard Method 5210B), while chemical oxygen demand (COD) was determined using the closed reflux colourimetric method (Standard Method 5220D).[13] Total coliform, faecal coliform, and E. coli were enumerated using the multiple tube fermentation technique as per Standard Methods 9221B and 9221E (12). Total plate count (TPC) was determined using the pour plate method on plate count agar, incubated at 35±0.5°C for 48 hours.[14] Heavy metals (Cu, Zn, Pb, and Cd) were analyzed using Atomic Absorption Spectrophotometry (Perkin Elmer AAnalyst 800) following acid digestion as per EPA Method 3005A.[15] Quality control measures included method blanks, certified reference materials, and duplicate samples. Data analysis was performed using SPSS version 25.0. Descriptive statistics were calculated, and results were compared with WHO drinking water guidelines.

RESULTS

Table 1 indicates slight acidic to alkaline conditions across the sampling sites.

Table 1: Physico-chemical parameters of drinking water samples collected from underground pressure pumps across Tehsil Domel, District Bannu

Location	BOD mg/L	COD mg/L	TDS mg/L	TSS mg/L	Conductivity µS/cm	Salinity mg/L	pH
Jangikala Perbakhil	5.32	12	438	09	644	0.12	06
Jaboor Khil	4.61	9.42	630	05	585	0.21	06
Abeed Khil	4.06	10.2	455	04	666	0	07
Maleng Kila	6.32	9.61	487	04	704	0.08	06
Doodi Khil	4.89	8.51	447	06	647	0.11	05
Khurgi	4.5	8.8	739	14	743	0	06
Jandik Kila	4.84	13.2	418	04	637	0.11	06
Zindi Kila	4.22	9.7	457	04	728	0.07	06
Gholamjan Kila	4.48	9.8	696	04	682	0.08	07
Ziraki	4.87	9	459	05	625	0.12	05
Domail City	4.98	8.7	445	05	646	0.1	07
Maisaar Khil	4.96	9.1	841	10	671	0.09	06
Musa Khil	4.43	15	412	04	714	0	07
Said Khil	4.92	9	490	04	1729	0.1	06
Bezan Khil	6.71	14	651	06	538	0.1	05
Umer Zai	4.76	8	429	05	678	0.06	07
Painda Khil	4.6	9.7	416	05	491	0.07	07
Ghani Khil	4.82	9.5	481	05	463	0.1	06
Sperki	4.63	14	411	04	739	0	07
Bodin Khil	6.89	8.6	863	05	751	0.07	05
Patol Khil	4.13	9.3	721	11	589	0.1	06
Kamar Kala	4.82	8.8	467	05	649	0.06	05
Mangal Mela	6.36	8.2	611	14	588	0.08	07
Sarki Khil	4.23	9	434	05	1697	0.09	06
Landi Jalandhar	4.61	9.4	413	04	621	0.06	06
Abad Khil	4.96	8.4	541	04	431	0.1	06
Mahajir Camp	4.965	11.5	497	05	474	0.12	07
Edil Khil	4.78	9.3	457	05	706	0.13	06
Bakir Khil	5.61	8.6	617	11	759	0.09	07
Kaama Chaashmi	4.18	8.9	437	18	569	0	06
Bara Chashmi	6.32	10	683	05	778	0	08
Spina Tangi	4.76	7.5	439	04	1715	0.09	05
Olegi	4.33	9.5	690	03	590	0.1	06
Oleegi Musa Khil	4.57	8.31	428	03	657	0.1	07
Maani Kila	6.88	7.9	519	11	693	0.07	07
Marghali Pirbakhil	4.29	9	431	04	1508	0.086	06
Sed Rawand	4.78	8.8	566	03	419	0	05
Dogar Umerzai	4.95	9.7	497	05	467	0	06
Sinzaar Khil	4.97	8.6	415	03	634	0.14	07
Maasti Khil	4.12	11	423	05	729	0.11	06

Table 2 findings indicate localized contamination of lead and cadmium in certain areas, posing potential health risks to consumers.

Table 2: Heavy metal concentrations in drinking water samples collected from underground pressure pumps across Tehsil Domel, District Bannu

Location	Pb mg/L	Cd mg/L	Zn mg/L	Cu mg/L	Ag mg/L
	Normal values	Normal Values	Normal Values	Normal Values	Normal Values
	0.01	0.001	0.01-0.05	02	0.005-0.05
Jangi Perbakhil	0.024	0.002	00	0.02	00
Jaboor Khil	00	0.001	0.015	0.006	0.005
Abeed Khil	0.053	0.008	0.052	0.012	00
Malaang Kila	00	0.001	00	0.004	00
Doodi Khil	0.024	00	0.042	0.01	0.003
Khoorgai	0.027	0.001	0.02	0.02	0.08
Jandek Kila	0.033	00	0.013	00	0.01
Zeendi Kila	0.044	00	00	0.001	00
Ghulaam Jan Kila	0.0066	0.003	00	0.006	00
Zeeraki	0.035	0.002	0.015	00	00
Domail City	0.004	00	0.01	0.01	0.003
Maisaar Khil	0.02	0.001	0.032	0.007	0.002
Musa Khil	00	0.003	0.052	0.005	0.001
Sed Khil	0.04	0.001	0.07	0.001	00
Beezan Khil	0.028	00	0.004	00	0.08
Umarzi	0.045	0.008	00	00	0.005
Painda Khil	0.074	0.002	0.01	0.02	00
Ghaani Khil	00	00	0.05	0.04	00
Spirki	0.034	0.004	00	0.07	0.002
Boodin Khil	0.01	0.004	0.063	00	00
Patool Khil	0.05	0.004	0.03	0.002	0
Kaamar Kila	0.028	0.005	00	0.007	0.004
Mangel Mila	0.006	00	0.04	00	0.001
Serki Khil	0.034	0.002	0.015	00	0.05
Laandi Jalendar	0.04	0.008	0.014	0.001	00
Abaad Khil	0.025	0.001	0.014	0.004	0.004
Majar Camp	00	0.004	00	0.00	0.004
Eidal Khil	0.005	00	0.04	0.005	0.002
Baakar Khil	0.001	0.001	0.01	0.005	00
Kaama Chaashmi	0.04	0.004	00	0.004	00
Bara Chasahmi	0.005	0.005	0.015	00	00
Speena Tangi	00	0.001	0.012	0.006	0.08
Oligi	0.01	00	0.042	00	0.002
Oleegi Mosa Khil	0.034	0.009	0.016	0.001	0.002
Mani Kila	0.074	0.001	00	00	00
Marghaali Pirbakhil	00	0.002	0.013	0.002	0.02
Sed Rawand	0.025	00	0.011	0.005	00
Doger Umarzi	0.071	0.007	00	00	00
Sinzar Khil	0.02	0.004	0.015	0.006	0.005
MaastiKhil	0.024	0.001	0.052	0.002	0.08

Table 3 findings highlight the need for immediate intervention to ensure the safety of drinking water in the study area.

Table 3: Bacteriological analysis of drinking water samples collected from underground pressure pumps across Tehsil Domel, District Bannu

Location	TPC CFU/ml	Coliform Bacteria (MPN/100 ml)	Faecal Coliform (MPN/100 ml)	E. coli
Jangii Pirbakhil	113	<1.1	<1.1	Negative
Jaboor Khil	120	< 1.1	<1.1	Negative
Abed Khil	160	2.2	1.1	Negative
Maalang Kala	230	3.6	<1.1	Positive
Dodi Khil	335	23	2.2	Positive
Khoorgai	256	9.2	<1.1	Negative
Jandek Kila	470	2.2	3.6	Negative
Zindi Kila	91	<1.1	<1.1	Negative
Ghulam Jaan Kila	276	3.6	<1.1	Negative
Zeeraki	88	<1.1	<1.1	Negative
Domail City	267	3.6	2.2	Negative
Maisaar Khil	97	<1.1	<1.1	Negative
Musa Khil	178	2.2	2.2	Negative
Sed Khil	245	9.2	<1.1	Negative
Beezan Khil	398	5.1	9.2	Positive
Umarzai	94	<1.1	<1.1	Negative
Painda Khil	134	<1.1	1.1	Negative
Ghaani Khil	277	3.6	2.2	Negative
Speerki	132	2.2	<1.1	Negative
Boden Khil	561	3.6	9.2	Positive
Patool Khil	290	3.3	<1.1	Negative
Kamaar Kala	86	<1.1	<1.1	Negative
Mangal Mela	121	<1.1	1.1	Negative
Serki Khil	245	9.2	1.1	Negative
Laandi Jilandar	75	<1.1	<1.1	Negative
Abaad Khil	120	1.2	<1.1	Negative
Majar Camp	160	<1.1	2.2	Negative
Eidal Khil	230	9.2	1.1	Negative
Bakkar Khil	335	5.1	<1.1	Negative
Kama Chaashmi	256	9.2	<1.1	Negative
Bara Chaashmi	470	2.2	9.2	Positive
Spina Tangi	91	<1.1	<1.1	Negative
Olegi	276	3.3	2.2	Negative
Oleegi Musa Khil	88	<1.1	<1.1	Negative
Maani Kila	296	9.2	<1.1	Negative
Marghalii Perbakhil	92	<1.1	1.1	Negative
Sed Rawand	144	1.1	2.2	Negative
Dogar Umerzai	273	3.6	<1.1	Negative
Sinzar Khil	139	<1.1	2.2	Negative
Masti Khil	566	6.9	9.2	Positive

DISCUSSION

Our findings revealed significant deviations in several physico-chemical parameters from WHO standards across the study area. The elevated levels of TSS (23% of samples) and TDS (37% of samples) align with findings by Rahman et al. (2022) in a similar geological setting, where they reported 31% of groundwater samples exceeding WHO limits for TDS in crystalline aquifer.[16,17] The observed BOD (20%) and COD (17.5%) elevations suggest organic contamination, comparable to findings by Ahmed et al. (2022) in rural groundwater sources.[18] The acidic pH values recorded in several locations present a dual concern: potential gastrointestinal health impacts and infrastructure degradation. Similar pH-related challenges were documented by Kumar et al. (2024) in groundwater systems of semi-arid regions, where 15% of samples showed pH values below WHO standards.[19,20] The elevated concentrations of Pb and Cd in specific locations (particularly in Mani Kila and Painda Khil for Pb, and Oleegi Mosa Khil for Cd) represent a significant public health concern. These findings parallel recent studies by Zhang et al. (2023), who reported similar heavy metal contamination patterns in the groundwater of agricultural regions.[21] The observed pattern of metal contamination, particularly the elevated Pb and Cd levels, while Cu and Zn remained within permissible limits, suggests anthropogenic sources, primarily agricultural inputs, as noted in similar studies by Wilson, 2010.[22] The bacteriological analysis revealed levels of contamination in several locations. The high TPC values (>500 CFU/ml) in Masti Khil (566 CFU/ml) and Bodin Khil (561 CFU/ml) significantly exceed WHO standards (<100 CFU/ml). These findings are comparable to those reported by Tufail et al., 2024, who found similar bacterial loads in rural groundwater sources, attributing them to poor sanitation infrastructure.[23] The detection of *E. coli* in 15% of samples (six locations) indicates significant faecal contamination, correlating with findings by Andrade et al., 2022, who reported 12-18% *E. coli* prevalence in similar settings [24]. The highest bacterial contamination in Masti Khil, Bodin Khil, and Bara Chashmi suggests localized contamination sources, possibly due to proximity to waste disposal sites or agricultural activities, as similarly observed by Gwimbi et al., 2019.[25] The co-occurrence of multiple contaminants (both chemical and biological) in several locations presents a compound risk to public health. Recent meta-analyses by Adeola et al., 2024 demonstrate that such combined contamination can lead to increased incidence of waterborne diseases, particularly affecting vulnerable populations.[26] The presence of both heavy metals and faecal contamination in some locations suggests multiple contamination pathways that require integrated intervention strategies. The spatial distribution of contamination appears to be influenced by both natural (geological) and anthropogenic factors. The proximity to highlands and subsequent rock weathering, combined with agricultural practices, creates a complex contamination profile similar to that observed by Khan et al. (2023) in comparable geological settings.[27] The use of agrochemicals, as evidenced by metal contamination patterns, mirrors findings from recent studies by Noethen et al., 2024 on agricultural impacts on groundwater quality.[28]

LIMITATIONS

he limitations of this study include its focus on Tehsil Domel, District Bannu, limiting generalizability to other regions. It only analyzed underground pressure pump water, excluding other sources. Seasonal variations were not considered as sampling occurred at one point in time. Minor analytical uncertainties may arise despite quality control measures. The study assessed key contaminants but did not cover all potential pollutants, and it lacked a direct health impact analysis linking contamination to health outcomes.

CONCLUSIONS

This study highlights significant physico-chemical and bacteriological contamination in drinking water sources across Tehsil Domel, District Bannu. Elevated levels of TSS, TDS, BOD, COD, and heavy metals such as Pb and Cd, alongside the presence of E. coli in several locations, indicate serious public health risks. The findings underscore the urgent need for improved water quality management, regular monitoring, and public awareness campaigns to mitigate contamination sources and ensure safe drinking water for the local population.

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CONTRIBUTORS

1. ***Noor Zada Khan -*** *Concept & Design; Data Acquisition; Data Analysis/Interpretation; Drafting Manuscript; Critical Revision; Supervision; Final Approval*
2. ***Waheed Ullah*** *- Concept & Design; Data Acquisition; Data Analysis/Interpretation; Drafting Manuscript; Critical Revision; Supervision*
3. ***Zakir Ahmad*** *- Concept & Design; Data Acquisition; Data Analysis/Interpretation; Drafting Manuscript; Critical Revision*
4. ***Abdullah*** *- Data Acquisition; Data Analysis/Interpretation; Drafting Manuscript; Critical Revision*
5. ***Imad Tariq*** *- Concept & Design; Data Acquisition; Data Analysis/Interpretation; Drafting Manuscript; Critical Revision*
6. ***Fawad Inayat -*** *Concept & Design; Data Acquisition; Data Analysis/Interpretation; Drafting Manuscript; Critical Revision; Supervision*