PHYSICO-CHEMICAL AND MICROBIOLOGICAL ANALYSIS OF DRINKING WATER QUALITY AND EPIDEMIOLOGICAL STUDY OF DISTRICT NEELUM, AZAD JAMMU AND KASHMIR

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ABSTRACT

Quality of water is vital for sustaining healthy life and associated activities. More than a billion people in the developing world including Pakistan lack safe drinking water [1]. Whereas, nearly three billion people live without access to adequate sanitation systems necessary for reducing exposure to water-related diseases. In Pakistan, the calamity of the October 2005 earthquake tore apart a large area of Azad Jammu & Kashmir (AJK), including District Neelum. In this situation, not only water sources but water distribution systems were also badly damaged. In this regard, a comprehensive study was designed to investigate the condition of freshwater at sources (springs) and reservoirs, and their management and the diseases caused by the use of these source water.

Keywords: *Water Supply, AJK, Water contamination, Chemical and Microbial Contamination, Water-borne Diseases*

1. INTRODUCTION

All living things need water for their survival and the continuation of their lives. Throughout the world, water is present in huge amounts; nearly 70% of Earth s surface is covered with water. 97.5% of the total water is in oceans, which are salty and not fit for drinking. The 2.5 % of the remaining water is fresh water. Less than 1% of the total fresh water is useable. If proper methods are used to get fresh water and carefully applied, the existing resources of water are enough for the whole population of the world. Clean drinking water is important for prevention of diseases, and regulating body temperature [2].

Drinking or potable water has acceptable quality in terms of its physical, chemical and bacteriological parameters so that it can be used without short or long term harmful effects [3,4]. Humans have insufficient access to drinking water throughout the world and consume contaminated sources of water, which have objectionable levels of dissolved chemicals and a huge amount of pathogens. These can lead to widespread, acute and persistent diseases and is a major cause of death. Mostly, the disease-causing organisms are transmitted through drinking water from fecal source, because organic wastes serve as food for bacteria [5-8].

A huge amount of polluted water is returned to natural sources of water from the surrounding area and makes them hazardous as it carries pathogenic organisms and toxic chemicals [8]. Over large parts of the world, the most common contamination of raw water sources is due to anthropogenic activities, which are usually of two categories: chemical/physical and microbiological. Chemicals/physical contaminants are heavy metals, trace organic compound, total suspended solids, while *Coliform* bacteria, *E.Coli* and some other species of bacteria and viruses are microbiological parameters of contamination. Some of the disturbances that happen in study area in Neelum Valley are anthropogenic and natural. Anthropogenic disturbances are water extraction for irrigation, washing activities, toilet use, waste and littering, sewage inflow, picnic, animals, deforestation, etc., while natural disturbances are droughts, floods, snow melting, erosion, landslides and earthquake, etc [9].

The 21st century will open with one of the most essential unmet conditions of human development: universal access to basic water services. More than a billion people in the developing world are deficient in safe drinking-water, a necessity being taken for granted by the populations of developed countries. Nearly three billion people live without access to adequate sanitation systems necessary to diminish exposure to water-related diseases. The failure of the states, local organizations and international aid community to ensure these essential human requirements has led to substantial, unnecessary yet preventable human suffering. An estimated 14-30 thousand people, mostly young children and the elderly, die every day from water-related infections [10-11]. In the developing world, about 400 children below age of 5 years die per hour from water-borne diarrheal diseases [6]. Unsafe and hazardous water, poor sanitation and unhygienic conditions cause approximately 3.1% of annual deaths (1.7 million) and 3.7% (54.2 million) of the annual health encumber worldwide [5, 12].

Microbial pathogenic parameters are usually of greatest concern because of their immediate health risks. Disease-causing organisms are known as enteric pathogens because these microbes are commonly of fecal derivation and transmit through drinking water [13]. Since the pioneering epidemiology in the 1850 s, whereby the English physician John

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Snow recognized that cholera was waterborne, it is confirmed that water can cause the diseases in human beings [14], it has been observed that diarrhoea and other diseases in humans are caused by various pathogens which are transmitted through the use of potable water [5, 13,15]. In the faeces of all warm-blooded animals and some reptiles, common fecal indicator bacterium, *Escherichia coli* (E. coli), is responsible for cholera (*Vibrio cholerae*) and typhoid fevers (*Salmonella typhi and S. paratyphi*). These bacterial species are considered necessary to be isolated from drinking water by treatment, traditionally filtration and chlorination [1,16].

Dissolved minerals, gases, and organic constituents may create aesthetically disgusting color, taste and odors. Some chemicals may be noxious, and some of the dissolved organic ingredients have been shown to be carcinogenic. Turbidity in surface water is mostly caused due to the erosion of colloidal materials, such as clay, silt, rock fragments and metal oxide from soil [17]. Taste and odor problem is caused by turbidity, and it is not only unsightly but also hinders the distillation abilities of disinfectants [18]. Measurement of electric conductivity (EC) and its relation to cations and anions, and the total solid concentration has been widely used for pollution detection and monitoring the quality of agricultural and surface waters and in chemical oceanography for salinity determination [19]. The pH is of major importance in determining the corrosiveness of water. pH usually has no direct impact on water consumers. Irritation to the eyes, skin, and mucous membranes is due to exposure to extreme pH values. It may have an indirect effect on health because pH can affect the degree of deterioration of metals as well as disinfection efficiency [20].

It has been reported that atleast 52 nations are expected to face a severe deficiency of potable water, including half the world's population till 2025. In the next 25 years, water scarcity will be a major problem for about 3 billion people. Currently, the major issue of South Asia includes: non-availability or inadequate access to potable drinking water, outbreak of water-borne diseases, arsenic contamination of drinking water, seasonal limitation of availability of natural resource, depletion of fresh water aquifers and organic pollution [2].

The study area was badly affected by the 2005 earthquake and was cut off from the outside world. Due to this calamity most of water sources and supply schemes were also damaged badly. In 1998, the population of Neelum valley was 0.126 Million that has increased to 0.159 Million till 2006 [21]. In AJK, there is no municipality-supplied drinking water. For a long time, streams have been the main sources of drinking water for the locals. An unplanned disposal of a large volume of solid wastes, i.e., household, municipal, and industrial, contaminate the sources of water by pouring high concentrations of trace elements and other pollutants [6].

Access to protected and safe drinking water is indicated by the number of people using appropriate hygienic sources. These improved drinking water sources have household links, public standpipe, borehole condition, protected dug well, protected spring, and rain water collection. This assessment expected to indicate the impact of intense anthropogenic use of water quality in a densely populated mountainous area in the Neelum district region. The importance of such investigations is documented through the fact that a huge population is utilizing drinking water from unprotected springs. Water for house-holds is therefore often heavily contaminated and causes chronic and severe infections, especially in summertime. Although, throughout the Neelum Valley there are numerous springs, due to non-availability of well-structured water supply schemes, lack of sewage treatment or controlled sewage discharge, these water resources are being polluted. Such resources could be utilized for water supply to the surrounding settlement, if organized in cooperation with the local population.

This study was conducted to estimate the overall quality (physico-chemical) of different water sources in order to understand the pollution load; and to investigate the water quality with reference to physico-chemical and micro biological parameters in order to find out, the quality of water at source; to investigate the impact of water quality on human health and the types of water-related infections in local people during the past one year. The sites were selected with regard to anthropogenic use, and proximity to the settlements. Furthermore, the variability of springs in the district Neelum was investigated and suggestions for further water management were made.

For this study, 64 Water Supply Schemes (WSS) were surveyed in five union councils (UCs) of district Neelum and were found in bad physical conditions. Eleven (11) WSS have developed spring boxes, while only one was developed, maintained and fenced. On the other hand, 7 schemes were found to be protected from flood diversion channels and only 12 schemes had no stagnant water around the sources. However, water sources had evidence of microbiological contaminants from adjacent areas due to human and animal activities which were causing severe health problems. For the purpose of physico-chemical and microbial analyses, a total of 64 water samples were collected from five union councils (UCs) and analyzed in triplicate for different physico-chemical and microbiological characteristics. Results revealed that only three water samples out of 64 were found to have turbidity levels higher than permissible limits prescribed by World Health Organization. However, all the water samples showed presence of microbial contamination in the form of either total coliform, while presence of E. coli was confirmed from 52 out of 64 water samples. A questionnaire survey about water-borne diseases among five union councils and capital city of district Neelum was conducted.

According to the results, people irrespective of their age were affected by water borne diseases and infections, such as diarrhoea and dysentery (22.7%), cholera (12.2%), typhoid (4%), skin infection (9.2%), eye infection (9.2%), hepatitis (2.3%), intestinal worms (7.82%), gastrointestinal infection (7%), kidney infection (3.67%) and hemorrhagic fever (14.33%). Considering the overall results of this study, it can be concluded that water supply schemes of the district Neelum were not responsible for any significant physico-chemical contamination in water from sources. However, the presence of microbial contamination in water sources is the evidence of diseases and infection that were commonly ailing the inhabitants of district Neelum.

2. MATERIALS AND METHODS

2.1 Study Area

District Neelum is located in Azad Jammu & Kashmir (AJK), Pakistan. Neelum valley is about 200 km long bow-shaped deeply forested area. At remote areas in district Neelum, visits were made to different sites for the collection of water samples and information associated to the study area (Table-1). Meetings and interviews were conducted with local people to understand the background of the problem stated in the earlier parts of the paper.

2.2 Materials

Water Samples and Sampling: The water sampling in the field was started as per the planned programme. Sampling task was completed in five days, from 16th July to 20th July 2009. A total of 192 water samples were collected from 64 water supply schemes of five UCs. Generally, the water supply schemes in AJK, including Neelum valley have chiefly originated from natural springs and lakes. Two types of water samples were collected from each scheme separately, one for physico-chemical and the other for bacteriological analysis.

2.3 Methods

2.3.1 Physico-chemical Analysis

On-site analysis for physico-chemical parameters, i.e. pH, turbidity and electric conductivity and total dissolved solids, were conducted.

pH: The pH of water samples was determined in the field by using pH Meter (Oakton EcoTest Pocket). The meter was selected for testing samples due to its main features: +/- 0.1 per cent accuracy across full pH range; automatic temperature compensation; auto-buffer recognition and auto-calibration functions. Before measuring pH of water samples, the instrument was calibrated with distilled water.

Turbidity: Turbidity was measured using Waterproof Portable Turbidity Meter EUTECH TN 100, which was calibrated with standard turbidity suspensions, i.e. 0.02, 20 and 100 NTU (Nephelometric Turbidity Units). The sample was taken in specific crystal bottles that were inserted in the turbidity meter placed on plain surface. The reading was noted three times and average was taken.

Electric Conductivity (EC): Electric conductivity of the water sample was analyzed with the help of Hanna

Table-1: Sampling of Water Supply Schemes (WSS) from Union Councils of Distt. Neelum

S. No	Union council (UC)	Number of WSS
1	Bharian	36
2	Doodhnayal	06
3	Kail	01
4	Shah Kot	20
5	Sharda	01

EC Meter - HI-98304 Dist4, ITALY .

Total Dissolved Solid (TDS): The TDS in water samples was determined with the help of a TDS meter.

2.3.2 Microbial Analysis

Bacteriological analysis was also carried out in the field by using field testing kits, Delagua and MERCK, Germany. For analysis of bacteriological samples, standard protocol was adopted in the field.

Total Coliform: Microbiological analysis was also carried out in the field. To analyse total *Coliform* in water samples, the special Merck Kits were used. After taking samples, the Merck kit was placed at 37°C in incubator for 24 hours. After the required time the samples were analyzed.

Escherichia Coli: The Oxfam-DelAgua Water Testing Kit was used for analysis of *E.Coli*. After the collection of samples and applying standard procedures, the samples were placed at 44°C for 24 hours for quantitative analysis. On next day, the *E.Coli* colonies were counted and the total number was recorded.

2.4 Questionnaire Survey

Epidemiological health status of the local population was determined using the questionnaire survey. Questionnaire survey was completed with the help of a research team led by a Research Supervisor. The questionnaire survey was completed according to plan, from 16th July 2009 to 20th July 2009. From each of the five union councils and capital of District Neelum (Autmuqam), 20 families were interviewed about their health conditions during past one year.

The questionnaire included questions related to family information, age and sex composition of each family, water supply source, domestic water treatment (boiling or filteration), type of the water-borne diseases experienced (diarrhea and dysentery, cholera, typhoid, skin infection, eyes infection, hepatitis, intestinal worms, GIT infection, kidney infection) faced by the family during the past one year, number of days the patient suffered from illness, reason of disease, (poor/improper food, water-borne or other causes), number/frequency occurrence of disease during past one year, magnitude of the disease, and hospitalization.

2.5 Hospital Record

For the confirmation of water-borne diseases in the study area, the past two year, i.e., from July 2007 to July 2009, hospital records were obtained from Tehsil Headquarter Hospital, Autmuqam District Neelum. This data included total record of the patient consultations during that specific time period.

3. RESULTS AND DISCUSSION

3.1 Physico-chemical Analysis

On-site analysis for physico-chemical characteristics of water samples, i.e., pH, turbidity and EC and TDS, were conducted (Table-2).

pH: The prescribed limit of pH in fresh water by WHO is 6.5-8.5. The average pH value in all water samples of different schemes was 8.05. The analyzed samples of drinking water were within permissible limit for pH. The range of pH value in the analyzed water sample was 7.3 to 8.8, however most of the 60 samples were falling in the range of limits prescribed by WHO. Only 04 samples exceeded the WHO limit (Table-2).

Turbidity: The prescribed limit of turbidity of fresh water is 5 nephelometer turbidity units (NTU) in WHO and 5-25 in Pakistan Standards & Quality Control Authority (PSQCA) standards. In all the water samples collected, the minimum turbidity value was 0.08 and the maximum value was 9.3, and their average value was 1.45 NTU. The results showed that turbidity of 03 samples were higher than WHO standards.

Electric Conductivity (EC): There is no guideline value of electric conductivity in fresh water in WHO standards, but the water having E.C above than 500 μs/cm^3 is not considered good quality water. Average electrical conductivity of all the water samples of 64

Table-2: The Results of Physico-chemical Analyses

Parameters	Total No WSS	Value varies From-To	Average Conc	No. of WS Exceeding WHO STD
Turbidity	64	0.08-9.3 NTU	1.45 NTU	03
pH	64	7.3-8.8	8.05	04
EC	64	30-507 μs/cm^3	158.38 μs/cm^3	00
TDS	64	26.95-304.2 mg/l	87.341000 mg/l	00

Table-3: The Results of Microbiological Analysis

Microbial Parameters	Total No WSS	WSS within WHO STD	WSS Exceed WHO STD
Total Coliform	64	00	64
E.coli	64	12	52

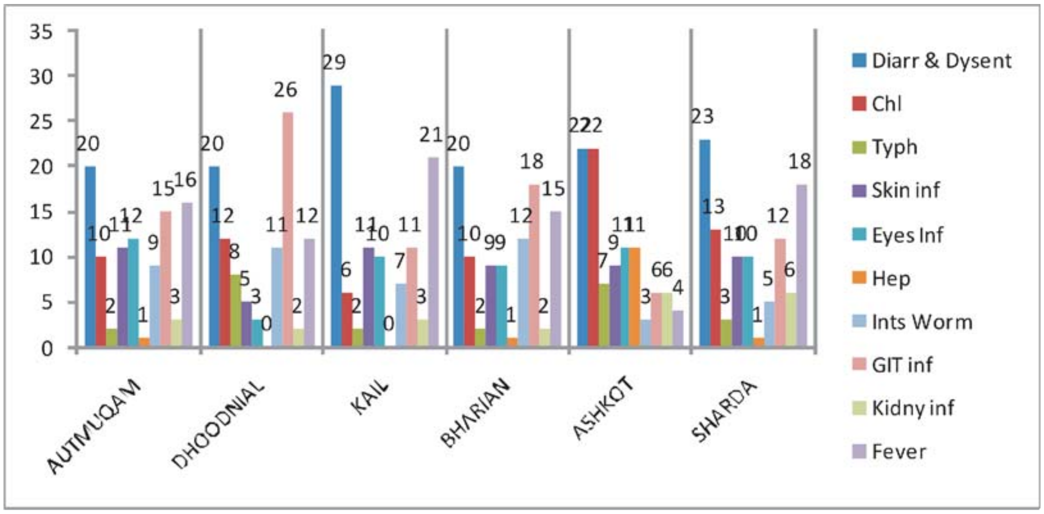

Figure-1: Percentages of each Type of Disease / Union Council Distribution

water supply schemes was 158.38, though it varied between 30μs/cm^3 to 507μs/cm^3. All 64 water samples in the five union councils were falling in the range.

Total Dissolved Solids (TDS): The prescribed limit for TDS in fresh water according to WHO standards is 1000 mg/l. Average TDS concentration in water samples was 87.34; however, TDS concentration in all water samples, varied from 26.95 to 304.2 mg/l. Most of the 57 samples were falling below the range of 150 mg/l. None of water samples exceeded the WHO limit (Table-2).

3.2 Microbial Analysis

Bacteriological analysis for total *coliforms* and *E. coli,* was also carried out in the field by using field testing kits provided by the local NGO. *Coliforms* are relatively easy to identify, and are usually present in larger numbers than more dangerous pathogens. *E. coli* as being the member of *coliform* bacteria is always taken as indicator of fecal pollution in water. The results of the present study positively indicated the presence of total *Coliform* in all water samples of the WSS, while the fecal *coliform* in the form of *E. Coli* was present in 52 out of 64 water samples of the water supply schemes (Table-3).

3.3 Population Survey for Disease Prevalence

Diseases caused by water are the most crucial concern when determining the quality of water. The enteric pathogens found in water include a broad variety of viruses, bacteria and protozoan parasites [12]. These pathogens cause severe and chronic health risks. In the study area, diarrhoea and dysentery was commonly found. As indicated in Figure-1 showing the percentages of the specific water-borne diseases, diarrhoea and dysentery were present in high ratios of the population than other diseases in each union council. Diarrhoea and dysentery were found prevalent among 20% population of population in Autmuqam, Bharian & Doodhnayal, 29% in Kail, 22% in Ashkot and 23% in Sharda, out of the recorded diseases. Figures of 12% in Doodhnayal, 22% in Ashkot and 13% in Sharda, cholera was observed. Typhoid was in the 8% population of Doodhnayal and 7% of Ashkot.

In the study area, a number of people were observed suffering from skin infections. Skin infection was found more common in Autmuqam and Kail (11%), and Sharda (10%). Whereas, eye infections were found in Autmuqam (12%), Kail and Sharda (10%), and Ashkot (11%). Hepatitis was observed in Ashkot (11%). Intestinal worms were found in Dhoodhnayal (11%), Bharian (12%). Gastro-Intestinal Tract (GIT) infections were common in Doodhnayal (26%), Bharian (18%), and Ashkot. Kidney infections were also observed and investigated in Ashkot and Sharda (6%). On the other hand, Hemorrhagic Fever was found in Autmuqam (16%), Kail (21%), Bharian (15%), and in Sharda (18%).

3.4 Hospital Record for Comparison and Verification of Water-borne Diseases in District Neelum

Figure-2 points out that the residents of district Neelum were infected and suffered from acute Diarrhoea (9.79%), Acute Jaundice Syndrome (0.02%), Bloody Diarrhoea (0.8%), Injuries (0.09%), Lower Respiratory Track Infection (10.15%), Malaria (0.06%), Measles (0%), Cholera (0%), Scabies (5.11%), Unexplained Fever (1.08%), Upper Respiratory Track Infection (25.05%) and Others (47.86%). Other problems, i.e., body aches, headache, depression or other psychiatric problems, head lice, joint pain etc, are included in other diseases.

4. CONCLUSIONS AND RECOMENDATIONS

Bacteriological contamination was evident in all water sources with few exceptions. Therefore, water-borne diseases were common and had infected a huge number of people in study area. However, no significant variation in physico-chemical quality parameters was observed. In the light of this study, it is recommended to adapt disinfection measures, such as boiling, chlorination, and use of direct sun light at domestic level. Water resources should be protected from mixing with human and animal wastes. Furthermore, to avoid house-hold waste contamination, separate laundry points for washing clothes should be constructed to reduce contamination due to soap and detergents. Quantitative and qualitative monitoring of water in the supply schemes with reference to bacteria and awareness about the water-borne diseases should be initiated as soon as possible.

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