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Assessment of water shed and drinking water quality at surface sources in Gilgit city, Pakistan

Yawar Abbas[1*], SalarAli[2], Nawazish Ali[3], Maryam Saleem[1], Syed Ali Haider[1], Miaoling Yau Gonzalez[4], Syed Naeem Abbas[5], Atta Rasool[6]

[1]*Department of Earth and Environmental Sciences, Bahria University, Islamabad, Pakistan*

[2]*Department of Environmental Sciences, Karakoram International University, Gilgit, Pakistan*

[3]*Department of Agriculture and Food Technology, Karakoram International University, Gilgit, Pakistan*

[4]*Department of Science, Technology and Society, Tsinghua University, China*

[5]*Forest, Park and Wildlife Department, Gilgit, Pakistan*

[6]*State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550002, China*

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Abstract

The results of the water samples were taken from different areas of Gilgit city Pakistan reflected bacteriological contamination could be a health risks to the population of Gilgit even though water filtration plants have been constructed at 9 places. Membrane filtration technique has been used for E.Coli determination by usig del Agua water testing kit. The overall objective of the survey was to check and make an assessment of drinking Water Quality of Gilgit city especially to investigate the bacteriological contamination of piped water supply from main Water Complexes and to identify the sources of contamination and to suggest remedial measures to upgrade the Quality of water to masses.The result shows that the highest number of E.coli were observed in the water samples from community tape (8/100ml).different points of Barmus Water Supply Complex Kashrot, Raja Bazaar and BarmusBala in April, 2008 and were tested for *E.coli*. The highest number of *E.coli* was observed in the water samples from House tape (Kashrot) and Market tape (Raja bazaar) (2/100ml) each having low risk while Results of all filtration plants found suitable for drinking with no bacteriological contamination and physical and chemicals tested i.e. pH, colour, odour, temperature and turbidity were within the permitted levels that shows proper filtration minimize the risk. ARCGIS 9.3 software has been used for the preparation OF GIS map of different locations of filtration plants on different locations of Gilgit city.

***Corresponding Author:** Yawar Abbas ✉ yawar_zaid@yahoo.com

Introduction

The area that drains into a common water body (e.g. stream,, pond, lake, river etc.) is called a watershed; this includes all surface water and groundwater, soil, vegetation and animals, and human activities contained within its area (Haas, 2001). Gilgit-Baltistan Watershed is a mountain watershed**.** In the Gilgit-Baltistan, precipitation varies complexly with the aspects of altitude and terrain i.e. it varies from 120 mm to 2000 mm with increasing altitude, the percentage of precipitation increases in the form of snow. In the Gilgit-Baltistan, the evaporation losses decrease with altitude as available energy decreases. Steepmountain slopes of the Gilgit-Baltistan cause water produced by rain or snowmelt on the surface to run off quickly into stream channels in many cases, shallow mountain soils and impermeable geologic formations of the Gilgit-Baltistan can provide little storage for soil moisture and ground water, as the soils are normally of extremely coarse textured (AKRSP, 1987). The natural water made available by the snow melt constitutes the run off in the form of streams and rivers. This flowing water is the sole source of fresh water used by the people for various purposes ranging from domestic to commercial and irrigational purposes. The quality of the catchment area affects the water courses. In turn the conditions in the river affect both the quality and quantity of fresh water (Zwick, 1992).

Changes in land use and other human activities alter the conditions in watershed, that resultantly affect the quality of water flowing on the land, with ultimate repercussions for humans as they withdraw this water for use (King and Schae, 2001). Livestock rearing in catchment area, deforestation, expansion of agriculture deep into watershed can contribute to eutrophication of water bodies along with alterations in other physical and chemical attributes and biota (García-Criado *et al.,* 1999). To evaluate the affect of these changes on water quality continuous and frequent monitoring is necessary (Barbour *et al*., 1999). Water quality assessment gives the baseline information on water safety. Consumption of water containing pathogenic organisms, toxic chemicals pose serious health risks to human health. Moreover, the physical condition of water (colour, taste and odour) might render it undrinkable (Kasangaki *et al.,* 2006).

According to the Pakistan National Water policy quoted by (Nanan *et al.,* 2003), drinking water means the water used for domestic purposes including drinking, cooking, hygiene and other domestic purposes. And the term “safe water” refers to the water complying with National Drinking Water Quality Standards. The surface-source water may be untreated or unfiltered (i.e. raw) water from lakes, streams, and rivers that is used for drinking. Finished water is that which is delivered to consumers after filtration. Usually, minimum treatment includes disinfection. Quality of drinking water may ultimately be defined as water that is safe for drinking and cooking (Ford *et al.,* 2000).Thus water quality can be categorized into three measurable criteria; (1) water free of Pathogens, (2) water with harmful chemicals below defined thresholds and physical parameters within acceptable ranges, and (3) water with radioactive compounds below defined thresholds (Health Canada, 2001). World Health Organization (WHO) have established guidelines that specify acceptable concentrations and limits (e.g. MCL: maximum contaminant levels; MAC: maximum acceptable concentrations) for many microbiological components, chemical/physical parameters and radiological amounts.

The objectives of the survey were to check and make an assessment of drinking Water Quality of Gilgit city especially to investigate the bacteriological contamination of piped water supply from main Water Complexes and to identify the sources of contamination and to suggest remedial measures to upgrade the Quality of water to masses.

Material and methods

Study Area

The study was carried out in the administrative

capital Gilgit of Gilgit-Baltistan situates at the confluence of Gilgit and Hunza Rivers. It is situated between 34-04 North latitude and 72-30 to 77-50 East longitudes. The city is surrounded by steep vertical mountains. The city is longitudinally spread in a North-West to South direction along the Gilgit River. Gilgit expand from bottoms up to steep slopes, subsequent to the topographic contours. The drainage basin consists of three streams locally called "Nullahs" *viz.* Jutial, Burmas and, Kargah which drain the water originating from snow and glacial melt into Gilgit River. Climate of the region is of desert type with annual precipitation of 145 mm in the bottom of the valley where city exists (Karrar and Iqbal, 2011).

Fig. 1. Shows the GPS points of water samples in different areas of Gilgit city.

This Study is conducted for the purpose of analysis of drinking water quality in Gilgit City for this purpose water samples from main Water Supply Complexes of Gilgit such as Jutial Water Supply Complex and Barmus, Kargah and Danyore Water Supply Complex) and analyzed for bacteriological contamination. The overall objective of the survey was to check and make an assessment of drinking Water Quality of Gilgit city especially to investigate the bacteriological contamination of piped water supply from main Water Complexes and to identify the sources of contamination and to suggest remedial measures to upgrade the Quality of water to masses. Clean drinking water and basic sanitation are necessary to prevent communicable diseases and to maintain a healthy quality of life. 'Kargah Nulllah' supplies water to 'Barmus' Water Supply Complex and water is supplied to Gilgit city through "Greater Water Supply System". Whereas Jutial Water Supply Complex is supplied through pipes from Jutial Nalah and further to Jutial town and Khomer. During survey it was observed in Jutial that pipelines of water distribution system is leaked and mixed with sewages. The whole complex is open and no sedimentation and filtration has been carried out in Jutial Complex. Gilgit-Baltistan Environmental Protection Agency (GB-EPA) conducted Water Quality Sampling and Testing of Jutial Water Supply Complex and Barmus Water Supply Complex according to WHO Guidelines and Pakistan.

Environmental Protection Agency (Pak-EPA)

procedures on 2nd April 2008.

Apparatus and Instruments

Polyethylene bottles, aqua culture photometer, Autoclave (Using moist heat for sterilization of media, Petri plates and water sampling bottles), Micro Biological Incubator (Incubation of Microbial culture), Hot Air Oven (Used for drying of substance/ filter paper), Magnet Stirrer (Used for proper mixing of solution by magnetic force), Hot plate with magnetic stirrer (used for proper mixing with temperature gradient), Turbidity meter (Used to check turbidity of water and waste water), Microscope (Used for microbial study), Wag Test (Physio chemical and Microbial testing kit) is used during analysis of water. Arc GIS 9.3 was used for the study area map and data were analyzed with Microsoft Excel 2007.

Chemicals and Reagents

Methanol and Lauryl Sulphate Broth.

Water sampling and analysis

To assess the water quality with the help of EPA–Gilgit a Water Quality Survey of main Water Supply Complex of Gilgit city and community taps were planned. For this purpose water samples from main Water Supply Complexes of Gilgit namely Jutial, Barmus, and Kargah Water Supply Complexes were taken and analyzed for bacteriological contamination. Water quality was determined through laboratory analysis of water samples for fecal contamination, pH, turbidity, color, odor, temperature and public consultations with various stakeholders from government and non-government as well as public and private sector. For confirmation of the acquired data and information two ways were adopted, Meetings were held with the relevant staff to find out the current management situation and Literature review of local and regional level research was carried out. Majority of the data used in this report is either taken from documents from Government i.e. population census reports and Aga Khan Development Network's work. The surveillance program has been prepared according to WHO Surveillance Monograph 1996 and the Sampling Procedure adopted is "Environmental Sample Rules, 2001" by Pak-EPA and Ministry of Environment Government of Pakistan. Samples were tested and analyzed through Del Agua Water Testing Kit, which employs the Membrane Filtration Technique and membrane lauryl Sulphate Broth as medium. A known volume of water is sucked through the membrane (fitted in the sterile membrane unit) with the help of Vacuum Pump. The membrane is then placed on the absorbent pad saturated with Membrane Lauryl Sulphate Broth in sterile Aluminum Petri dish. The plates are than incubated for 18 hours at 40-44°C. After incubation period all yellow colonies on the membrane were counted and reported in per 100 ml of water.

Results and discussions

Watershed Management Situation

Gilgit-Baltistan is home to largest conglomeration of Glaciers outside the poles. Glacial melting release large quantities of water which form streams, these streams merge to form rivers which finally come together to form the mighty Indus which contributes 60% of total water consumption in Pakistan. Seasonal variations create significant effect on the discharge of primary rivers resulting significant decrease in the discharge flow in peak winter seasons (ICIMOD, 2001). In Gilgit-Baltistan, due to aridity, vegetation can only survive in areas where either snow is available or water is made available through irrigation. The erosion is basically derived from geologic processes. The vegetation is concentrated around nullahs and streams. Thus channel erosion contributes significantly to the sediment transport. Therefore, different type of watershed management is needed compared to the wet mountains (Karrar and Iqbal, 2011).

Quality of Drinking water in Gilgit

According to AKRSP (1987) 89% of people in Gilgit city use surface water for drinking and other domestic purposes. WHO (1997) reports that more than 80%

diseases in the developing world are attributed to inadequate sanitation or to polluted water. Most of the patients visiting the DHQ Gilgit and Skardu have been found to have water born diseases. The most affected proportion of population consists of infants and women as children and women during pregnancy are more susceptible than adults. Despite its importance, water is said to be one of the most badly managed resources in the world and the same state of affairs exists in the Gilgit –Baltistan. The main factors responsible for degradations of water channels (main source of domestic use) in urban settlements include lack of sanitation facilities, absence of environmental legislations and competitive authority especially in the developing world.

Table 1. Shows water supply complexes Gilgit.

Water Supply Complex	Year	Month	Total No. of samples	Contaminated samples	Not contaminated
Jutial Water Supply Complex	2008	April	5	5	0
Barmus Water Supply Complex	2008	April	6	2	4
Central Gigit	2008	May	7	6	1

Samples were taken from the three water complexes on April 2, 2008. Five samples were taken from Jutial Water Supply Complex which are shown in Table 1, of which none of the samples were found to be contaminated. Four samples out of six taken from Barmus Supply complex showed contamination and remaining two showed no contamination. Samples taken from Central Gilgit showed high contamination where six out of seven samples were found contaminated with *E. col.* The reason for this high contamination can be traced in ill management of Supply complexes, leaking water distribution lines. Raw water from Nullah is diverted and supplied to the population in Central Gilgit and Jutial without filtration. In Central Gilgit there is no such means of drinking water treatment.

Table 2. Sampling from different Filtration plants in Gilgit city.

Sampling Point	E.coli/100ml water	of Colour	Odor	Taste	Risk
APSC Filtration Plant	0	Colorless	Non objectionable	Non objectionable	No Risk
CMH Hospital F.T	0	Colorless	Non objectionable	Non objectionable	No Risk
Boys Public School & College F.P	0	Colorless	Non objectionable	Non objectionable	No Risk
Khomer Chowk F.P	0	Colorless	Non objectionable	Non objectionable	No Risk
DHQH (Male) Filtration Plant	0	Colorless	Non objectionable	Non objectionable	No Risk
Girls High School No 2 F.T	0	Colorless	Non objectionable	Non objectionable	No Risk
Khomer Damote (BirgiliMuhallah) F.P	0	Colorless	Non objectionable	Non objectionable	No Risk
Air Port Chowk F.P	0	Colorless	Non objectionable	Non objectionable	No Risk
Air Port F.T	0	Colorless	Non objectionable	Non objectionable	No Risk
MuhammadiMuhallah F.P	0	Colorless	Non objectionable	Non objectionable	No Risk
PaltiniMuhallah F.P	0	Colorless	Non objectionable	Non objectionable	No Risk

The city is lacking mass water storage facility, where treatment could be possible. but unfortunately the dwellers of Gilgit and Jutial are using the contaminated water. Policies for the treatment of the drinking water is in pipe and expected to implement in 2016. Gilgit Development Authority (GDA) has made master plan for the treatment and safe disposal of the sewerage water, which is positive sign to

overcome cross contamination. The storage tanks are uncovered and wind deposits dust in the tanks. The presence of *E.coli* indicates recent faecal contamination and the potential presence of microorganisms capable of causing gastrointestinal diseases; pathogens in human and animal faeces pose the most immediate danger to public health. Health Canada (2014).

Samples were also taken from Water purification plants Installed by Government of Pakistan at various locations in Gilgit city (Fig 1) and assessed against Water standards made by WHO and Pakistan EPA. Table 2, shows the results. At all location water tested was found suitable for drinking with no bacteriological contamination and physical and chemicals tested i.e. pH, colour, odour, temperature and turbidity were within the permissible limits that shows proper filtration minimize the risk. The treated water in the filtration plants are not posing any serious disease to the inhabitants of the area.

Table 3. Classification of samples in different categories as per WHO guidelines.

S#	Sampling Points	Samples	E.coli/100ml			
			A	B	C	D
			0/100ml	1-10/100ml	11-100/100ml	101-1000/100ml
1	A	1	1	--	--	--
2	B	1	1	--	--	--
3	C	1	1	--	--	--
4	D	1	1	--	--	--

On April, 2008 samples were taken from five different points including main water source of Haidry Mohallah in Jutial water complex and were tested for E.coli. the highest number of E.coli were observed in the water samples from community tape (8/100ml) (Figure 2) followed by main source (7/100ml) school tape (6/100ml), house tape (3/100ml) and outlet (2/100ml). Where is the temperature of water (15C), (PH 7.6), turbidity (<5NTU). Above results shows the contamination exist at main source and minimum counts were recorded in out let of water supply complex due to some treatment, maximum countsat house&schooltape and more were recorded at community tape which shows the risk B=1-10/100ml (Low Risk) as shown in table 3. Reason is that many broken and leakage pipelines, improper piping and existence of contaminants near by the water supply line up to community tape.During survey it was observed in Jutial that pipelines of water distribution system is leaked and mixed with sewages. The whole complex is open and no sedimentation and filtration has been carried out in Jutial Complex.

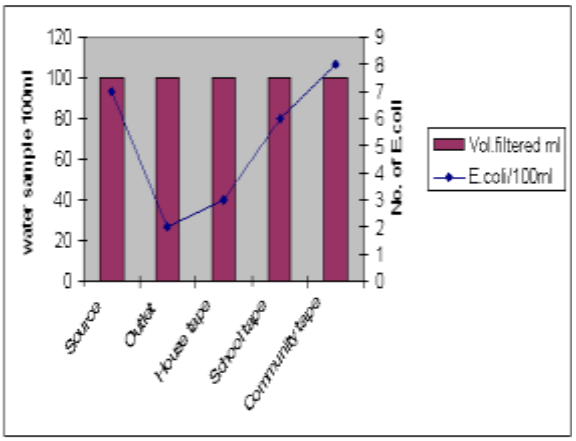

Fig. 2. Haidry Mohallah Jutial Water Supply Complex

Samples were taken from five different points of Barmus Water Supply Complex Kashrot, Raja Bazaar and BarmusBala in April, 2008 and were tested for *E.coli*. The highest number of *E.coli* was observed (Figure 3) in the water samples from House tape (Kashrot) and Market tape (Raja bazaar) (2/100ml) each having low risk while, no *E.coli* was observed in the other samples, that shows water in these areas has no bacteriological contamination. Whereas the temperature of water (17-21°C), (pH <6.8-7.8),

turbidity (< 5NTU), odour and taste were in normal range according to WHO standers.

Gilgit-Baltistan Environmental Protection Agency (GB-EPA) conducted Water Quality Sampling and Testing of Jutial Water Supply Complex and Barmus Water Supply Complex according to WHO Guidelines and Pakistan Environmental Protection Agency (Pak-EPA) procedures on 2nd April 2008.

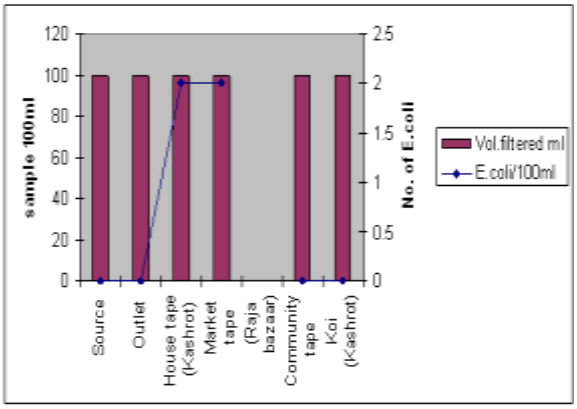

Fig. 3. Barmus Water Supply Complex.

Along with Water samples from water Supply complexes serving Gilgit city populace, samples were also taken from Water purification plants Installed by Government of Pakistan at various locations in Gilgit city and assessed against Water standards made by WHO and Pakistan EPA. Table 2, shows the results. At all location water tested was found suitable for drinking with no bacteriological contamination and physical and chemicals tested i.e. pH, colour, odour, temperature and turbidity were within the permitted levels.

Conclusion

Watershed management is vital to ensure sustainable supply of water for ecological and human purposes. But in the study area due to lack of management, lack of awareness among populace, exploitation of natural resources particularly deforestation have dire implications for watershed health. Healthy watershed ensures good water quality for human use, puts less pressure on water filtration and purification plants, and ensures high biological productivity. But in the study area, due to human interference in the form of logging, overgrazing by cattle and livestock, increased visits for recreation are causing watershed degradation. Results of the research showed that, the drinking water quality was better in Barmus Water supply complex compared to Jutial Water supply complex, where water samples showed higher bacterial contamination. But overall drinking water provided to the population has no health or very low health risks when compared to WHO and National drinking water standards.

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