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Water quality assessment of Gilgit river, using fecal and total coliform as indicators

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Abstract

Coliform bacteria have been used to evaluate the general quality of water. These bacteria can be found in the gut of both warm and cold-blooded organisms. Fecal coliform is a subset of this group. They have been characterized to grow at elevated temperatures and specifically associated with the fecal material of warm-blooded animals. Gilgit River was evaluated using coliforms (total coliform and fecal coliform) as indicators, in relation with physicochemical parameters such as biological oxygen demand (BOD), conductivity, dissolved oxygen (DO), nitrate, ph, phosphate, salinity, temperature, total dissolved solids (TDS) and total suspended solids (TSS). Monthly sampling was conducted from November 2011 to April 2012 in the upstream, midstream and downstream sections of the river. The multiple tube fermentation technique was used for the analysis of coliforms. FC values showed significant spatial variation ($p=0.004$) which could be ascribed to a lower level of biological pollutants in the upstream however, the difference in values across time was not significant. This implies that the river water was severely polluted at the time of sampling. The coliform bacteria did not show significant correlations ($p > 0.05$) with the physicochemical factors. A negative relationship was noted between coliforms with pH, DO and nitrate. This could be ascribed to the presence of organic pollutants coming from domestic and industrial discharges.

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Introduction

Coliform bacteria have been used to evaluate the general quality of water. They serve as indicators of contamination in a water source. Threats to water resources come from many sources; one of the most important is pollution. Sources of pollution include wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and storm runoff. Kelsey *et al.* (2004) found that storm water runoff from urban land uses are the primary source of fecal pollution. They found that proximity to areas with septic tanks and rainfall prior to the sampling date, are good predictors of fecal pollution. Also, Auer and Niehaus (1993) reported that the fecal coliform bacteria death rate is impacted by both solar radiance and water temperature. Young and Thackston (1999) found that fecal bacteria counts in urban tributaries were much higher in sewered basins than in nonsewered basins and in general were related to housing density, population, development, percent impervious area, and domestic animal density. Mallin and colleagues stated that fecal coliform densities have strong positive correlations with turbidity, and strong negative correlations with salinity (as cited in Eleria and Vogel, 2005). A study of the Ib River in Mahanadi Basin in India showed that the BOD and high total coliform are the two parameters that were mainly responsible for lowering the water quality.

Water that is meant for human and domestic uses should therefore be treated. Since it is difficult, time consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for coliforms. In addition, testing for coliform bacteria is faster and cheaper than testing for specific organisms and pathogens. Monitoring the fecal and total coliform is an essential component of any water quality study. In addition to the possible health risk associated with the presence of elevated levels of fecal bacteria, they can also cause cloudy water, unpleasant odors, and an increased oxygen demand. This study analyzed the water quality of Gilgit river in terms of coliform levels. Specifically, it aimed to: (1) measure the TC and FC levels; (2) compare the coliform levels in space and time and (3) correlate the coliform values with the physicochemical parameters.

Materials and methods

Sample Collection and Handling

Three sampling sites were established along the stretch of Gilgit River namely upstream, midstream and downstream (Fig. 1).

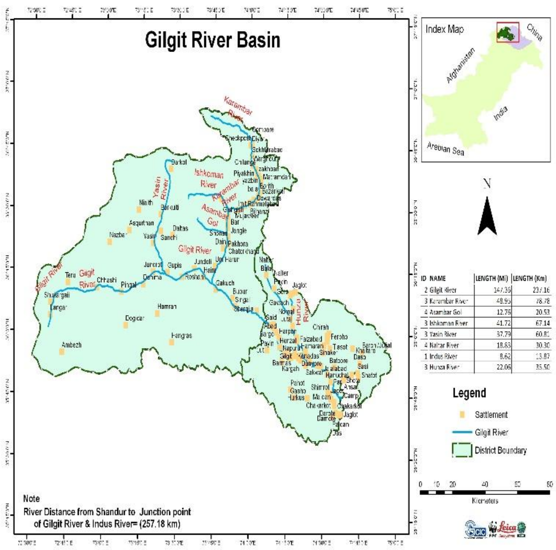

Fig. 1. Map of the sampling site.

Sampling for the coliform bacteria was conducted on a monthly basis from November 2011 to April 2012. The measurement and field sampling protocols were adopted from the Sampling Protocols for River and Stream Water Quality Monitoring and Field Sampling, and Measurement Protocols for the Watershed Assessments Section (Mills *et al.*, 1985).Water samples were collected at approximately 6in from the stream center and were transferred directly into sterilized containers.

Each sample was labeled, placed in cooler with cube ice and kept at temperature of 0°C and not higher than 4°C. All samples were processed immediately in the laboratory following collection. Laboratory procedures for the analyses of the coliform bacteria were performed in accordance with the Manchester Environmental Laboratory Manual 2005 (MEL 2005) protocols. The Multiple Tube Fermentation Technique (MTFT) was used in the analysis of the collected sample. The results were expressed in terms of the Most Probable Number (MPN).

The Study Sites

The headwater of Gilgit River comes from the mountainous region Starting Point = 36°4'37.05"N,72°32'11.34"E The upstream site is the original water district of the municipality as this is located in the watershed area. The river banks were lined with abundant canopy trees and plants. Large boulders of rocks were evident in the area. The river water is remarkably clear and free from unpleasant odor. Consequently, the river has been used for bathing, washing, and even for drinking. Some residents were also engaged in small scale quarrying resulting in the river‟s irregular morphometry .

Source:Fecal and total coliform levels of Gilgit river (Bensig *et al.*,2014)

The midstream site (35°54'51.19"N, 74°22'4.48"E) of Gilgit River has a width of 25 m.The river banks were slightly modified with patches of unfinished grouted rip rap walls. One side of the river bank was lined with houses while the other side remains free of human settlement with patches of bamboo canopy, and other tall plants. The river water is relatively clear and transparent. However, garbage and other wastes, mostly plastics and leaf litter, were observed. Further, waste water from sewer pipes, communal (laundry) washing area and backyard piggery were released into the river. Aside from sand and pebble quarrying, children bathing in the river were apparent.

Gilgit River traversed downstream 35°44'32.93"N, 74°37'28.09"E end point starts indus. The river used to be the main water source for the plantations. The downstream site is located in a highly urbanized area. Concrete riprap walls lined the entire stretch of the river. The river width measured 10.08 m. Apparently, about 70% of the households situated in the river banks have piggeries. Moreover, sewer pipes were also noticeably draining into the river. The river water gives off a foul odor with a dark greenish brown color.

Data Analysis

Field and laboratory results were collated and organized using Excel spreadsheet software. The Pearson correlation was employed to determine the relationship between coliform bacteria and the physicochemical parameters; and to find out the direction of the relationship–whether it is positive or negative. Analysis was limited to evaluation of TC and FC bacteria.

Results and discussion

Fecal and total coliform counts

During the study period, the downstream site in the month of November showed the highest FC count ($3.3x10^{11}$ MPN/100ml) while the midstream site had the lowest value of $4x10^3$ MPN/100ml during the January sampling (Fig. 2a). The results were quite reasonable since downstream areas generally received inputs from both upstream and midstream. It is This could be attributed to the rain that occurred the important to note though that there was a sudden night before sampling. decline of FC value in the midstream during January.

The results coincided with the findings of Ajeagah *et al.* (2011) that bacteria concentrations in the river tend to increase during the hydrograph rise and decrease during the hydrograph recession due to watershed wash off processes. The FC results showed no significant temporal variation (p=0.771). This could mean that regardless of month, the river is always polluted. Mean FC values, however, showed significant spatial variation at p=0.004 (Fig. 2b). This could be ascribed to the lower FC levels in the upstream as a consequence to a minimal input of biological pollutants. Unlike the midstream and downstream areas, the upstream lies in the rural/mountainous area. The river banks were lined with abundant canopy trees and plants. The river water was remarkably clear and free from unpleasant odor. Moreover, the sampling site was free from households which could be the potential source for FC. Distinctively, the result showed high FC levels in the downstream. Prevailing factors could be due not only to population density but also to the proximity of the downstream site to the landfill. Fig. 3 shows that the downstream site during the January sampling had the highest TC value of 1.7×10^{13} MPN/100ml whereas the lowest value of 2.4×10^{4} MPN/100ml came from the upstream site during the December sampling. However, the mean TC values did not differ significantly through time (p=0.771) and among stations (p=0.235)

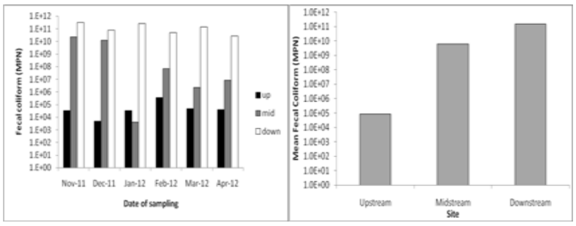

Fig. 2. Fecal coliform values by month (a) and by site (b), Gilgit rive.

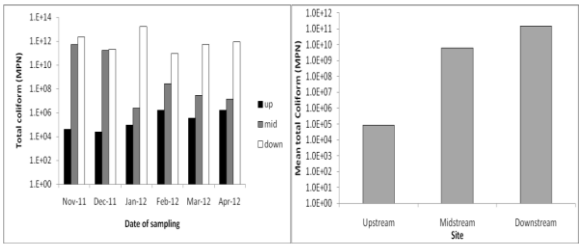

Fig. 3. Total coliform values by month (a) and by site (b), Gilgit River.

The high TC level in the downstream during January could be due to it being a recipient site of all wastes from the upper stations and also because of the slight rain that occurred on sampling day. Similarly, the results concurred with the findings of Wandiga (2010) that high coliform counts normally occur during the rainy seasons. This is because storm waters are the detergent of the plains and bushes where human and animal wastes are deposited. The coliform count during the dry season is low since most biological deposits only come from sewage disposed through broken sewers and storm water pipes which become the major source of river water. The high TC count implies that the river water was severely polluted at the time of sampling.

Correlations

Simultaneously, the study entitled “Water Quality Assessment of Gilgit river was carried out Using Physicochemical Parameters as Indicators” was also carried out. As such, the data of the physicochemical factors from the aforementioned study were used for the correlation of TC and FC.

Statistically, both fecal and total coliform bacteria did not show significant correlation (p>0.05) with the tested physicochemical parameters. However, a negative relationship was noted among coliforms with pH, DO and nitrate (Table 1).

Table 1. Pearson's correlation coefficients between selected physicochemical factors of Gilgit River.

	Temp (°C)	pH	Conductivity (µS/cm)	Salinity (ppt)	TDS (mg/L)	TSS (mg/L)	DO (mg/L)	BOD (mg/L)	Nitrate (mg-/L) NO_3	Phosphate (mg PO_4^{3-}/L)
Fecal Coliform	0.385	-0.293	0.815	0.567	0.594	0.478	-0.491	0.162	-0.361	0.635
Total Coliform	0.133	-0.110	0.551	0.574	0.527	0.139	-0.182	0.199	-0.007	0.255

**Correlation is significant at the 0.01 level (2 tailed)

* Correlation is significant at the 0.05 level (2 tailed)

Source: Water Quality Assessment of Gilgit River Pakistan Using Physicochemical Parameters, 2012.

Coliform bacteria exhibit aerobic respiration during decomposition process. As a result, DO levels in the water decreases as bacterial density increases.

Similarly, a negative relationship existed between nitrate concentration and coliform levels. The data showed elevated levels of nitrate in the water which could be attributed coming from agricultural runoffs and household effluent (Kazmi and Khan, 2005). This creates as suitable environment for coliform growth as nitrate concentration becomes abundant. In turn, the nitrate concentration deceases as result of coliform uptake.

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