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Water quality assessment using macroinvertebrates as indicator in sultanabad stream (Nallah), Gilgit, Gilgit-Baltistan, Pakistan

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Abstract

This preliminary research was to evaluate the water quality assessment through macro invertebrates and selected physio-chemical parameters in Sultanabad Stream (Nallah in Urdu). Samples were collected from six different locations started from upstream to the downstream of the Stream (Nallah). Sampling was done using standard methods such as Macroinvertebrates collection through Kick net having 500um mesh size and selected physio-chemical parameters such as dissolved oxygen (DO), Total Dissolved Solids (TDS), temperature and pH. Most of the physio-chemical parameters were measured using multi parameter probe at the sampling occasion except Electrical Conductivity (EC), Nitrites and Nitrates which were measured using Conductivity meter and nitrate strips in the laboratory respectively. A total of 718 macro invertebrates were recorded comprising of Chironomidae (Diptera) (78%) being most dominant group, Ephemeroptera (17%), Plecoptera (4%) and Trichoptera (1%). Sensitive group of macro invertebrates like Ephemeroptera, Trichoptera and Plecoptera were abundant at upstream and at junction point as compare to other locations of the Stream, indicating good water quality at upstream. One way ANOVA showed significant difference of most of water quality parameters with respect to various locations. Result of overall mean physio-chemical properties of the stream were like alkaline pH (7.4), low temperature (8.9 ^{o}C), high DO (10 mg/l), low TDS (284.4 mg/l), low nitrites (0.88 mg/l) and nitrates (8.8 mg/l) and low EC (467 µS/cm).

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Introduction

Streams and rivers are source of freshwater which form the most widespread type of surface freshwater habitat in the world (Zwick, 1992). Rivers irrigate catchments, the latter largely shaped by the action of its flow. In contrast, the quality of the catchment area also affects the rivers. In turn, the conditions in the river affect both the quantity and quality of our most vital resource that is clean freshwater (Zwick, 1992). Rivers are highly vulnerable to change in land use and other human activities as they are on the receiving end of the drainage system of any catchment area (King and Schael, 2001).

Rivers and Lakes are ecosystems of great ecological value with a rich fauna that consists of communities with a complex structure and high biological value. However, their special typology makes them fragile and vulnerable to environmental changes, especially those related to disturbances of anthropogenic origin, which often imply irreversible degradation of their biota (Beasley & Kneale, 2003; Dahl *et al.,* 2004). Agriculture run off due to use of high amount of fertilizers and pesticides, has also contributed significantly to eutrophication and contamination of aquatic ecosystems (García-Criado *et al.,* 1999) The quality of stream water is affected by changes in the stream's watershed which is caused by agriculture, clear-cutting, destruction of wetlands, and urbanization. These developments cause changes in water chemistry, biota, and physical characteristics of the stream (Allan, 1995). To determine the influence of these changes on a stream's water quality frequent and constant monitoring is necessary (Barbour *et al.*, 1999). Freshwater ecosystems experience a great pressure by human activities that alter the physical, chemical, and biological processes associated with water resources. Therefore, the protection and maintenance of high-quality lotic and lentic water have become an increasingly important issue in recent years (Shrestha, 1990; Jha *et al.,* 2010).

The quality of rivers and streams has been monitored using chemical, physical and biological measures (Rosenberg and Resh 1993).The traditional means of assessing the impacts of pollution on water bodies were through the measurement of physical and chemical parameters (Rosenberg and Resh, 1993; Vermeulen, 1995; Kasangaki *et al.*, 2006). Biological monitoring, or bio monitoring, is the use of living organisms to determine the condition of the environment. Biological assessment of stream conditions provides information needed for the conservation of biodiversity (Simaika and Samways, 2009).In streams, bio monitoring can be done using benthic macro invertebrates and fish but benthic macro invertebrates are generally the group of choice (Voshell *et al.*, 1997). Macroinvertebrates comprises of diverse group, having ecological significance of macroscopic size normally more than 1mm, living permanently or during certain periods of their life cycle linked to the aquatic ecosystem. They include insects, crustaceans, annelids, mollusks, leeches, etc. Macro invertebrates and water quality are interrelated to each other, as macro invertebrates are a potential indicator of water quality. Benthic macro invertebrates are one of the most common groups of organisms used to assess the health of aquatic ecosystem (Rosenberg and Resh, 1993).

Main objective of this preliminary study is to assess ecological health of Sultanabad stream (Nallah) using macroinvertebrates as indicators. However some of the specific objectives are:

1. To Assess ecological health of stream using macroinvertebrates as an indicator.
2. To study some of selected physio-chemical properties of stream (water).
3. To document macroinvertebrates and create a baseline data for future research.

Materials and methods

Study Area

Gilgit-Baltistan is blessed with rivers and lakes fed by glaciers and springs. This study was conducted in one of the stream locally called 'Nallah' located in Sultanabad, Danyore which is situated on 74.378E to 35.947N, some 20 Km north-east of Gilgit city at an altitude of 1509m. Village exists on the alluvial fans of Danyore Nullah and Khinzer Nullah with hamlets spreading from mountain foot to bank of Hunza river that passes west to south of the village. Majority of the population in village is associated with substantial farming and cattle rearing. The climate in Sultanabad is called a desert climate throughout the year; there is very little rainfall about 145 mm of precipitation falls annually. The driest month is November with 2 mm and most precipitation falls in May, with an average of 31 mm. The average annual temperature in Sultanabad is 16.4 °C. The warmest month of the year is July and August with an average temperature of 28.2 °C. The coldest month is observed in January with average temperature of 3.5 °C. (WWF Pakistan, 2012).

Danyore and Sultanabad share Danyore Nullah as common source of water that flows dividing the two villages and empties into Hunza River acting as a natural boundary. It is fed by snow melt and "Darbund Glacier" that originates from south-western face of Rakaposhi mountain chain at an elevation of more than 4500 meters, which is Perennial River (WWF Pakistan, 2012).

Research Design

Field and lab Methods

Samples were collected from six locations starting from upstream head water, Water tank, and tank inlet, residential area, near Sultanabad Bridge and at the junction point where Sultanabad stream joins Hunza River. Macroinvertebrates were collected using 500 µm mesh net, where rocks and other benthic material were disturbed to flow downstream to mesh net. Samples were transferred into the bottles and preserved with 75% alcohol in the field. Macroinvertebrates were also picked from 4 to five stones by hand with the help of forecep. Three water samples were collected from each sampling locations for chemical analysis further samples were dated and labeled.

Physio-chemical parameters such as pH, Temperature, Total Dissolved Solids and Dissolve Oxygen of stream were measured from all the sites where macro invertebrates collected through standard methods (using multi parameter probe). Electrical Conductivity (EC) is measured using EC meter while Nitrite and Nitrates were measured by using strip

Results and discussion

Macro invertebrate's composition and Abundance in overall Stream

Overall macro invertebrates were recorded comprising of Diptera (78%), Ephemeroptera (17%), Trichoptera (1%) and Plecoptera (4%) (fig. 1). Sensitive group of macro invertebrates such as Plecoptera, Trichoptera and Ephemeroptera abundance were higher in junction point and in upstream as compare to other sites of the Stream indicating better ecological health.

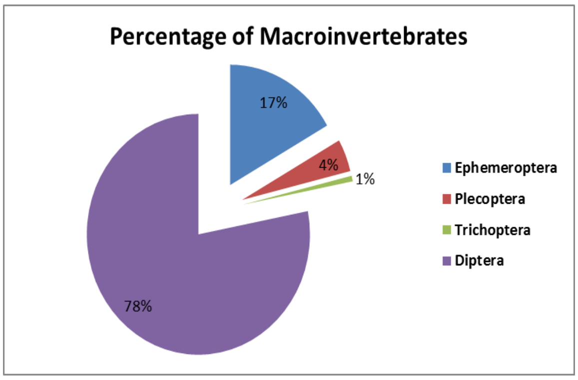

Fig. 1. Abundance of macro invertebrates in percentage.

Macro invertebrate analyses are also a powerful means for assessment of aquatic Systems. They incorporate chemical, physical, and biological stresses over space and time, they are excellent indicators of ecosystem health because they respond surprisingly to many perturbations, and they are often easier and less expensive to analyze than chemicals or fish (Gerritson *et al.*, 1998; Barbour *et al.*, 1999).

The presence and absence of macroinvertebrates indicated the degree of pollution for a variety of reasons, invertebrates are extremely important in the functioning of wetland, and thus can be viewed as surrogates for wetland wealth. First, from a logistic standpoint that they make good study specimens, because, they are abundant, readily surveyed, and taxonomically rich (Dodson, 2001).Macro invertebrates can indicate the pollution ecology of streams and rivers depending on the different taxa and their relative abundance (PWP, 2008).

Macro invertebrate's composition and Abundance at various locations of the Stream

One way ANOVA showed significant difference of most of water quality parameters with respect to various locations (Table 1).pH, DO, EC, Nitrate, Nitrite, Water temperature, TDS, and Biological indicators showed significant variation with respect to different locations of the stream.

Table 1. One way ANOVA (F values) Result for water quality parameters with respect to various locations.

	pH	DO (mg/l)	EC (µS/cm)	Nitrite (mg/l)	Nitrate (mg/l)	Temperature (°C)	TDS (mg/l)	Macroinvertebrates Abundance	Macroinvertebrates Taxa Richness
Locations	8.6**	26**	3.6*	283**	57**	129**	3.2**	16.4**	13.9**

Note: *, **, Indicates $p<0.05$, $p< 0.001$ and "ns" non-significant respectively.

Overall abundance of macroinvertebrates (fig. 2) found highest at Tank Inlet and Populated or residential area compared to other locations. While taxa richness was highest at upstream and junction point indicating more diverse community of macroinvertebrates (fig. 3).

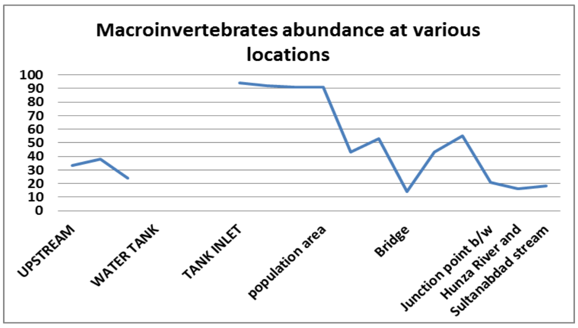

Fig. 2. Abundance of macro invertebrates in Sultanabad Stream at various locations.

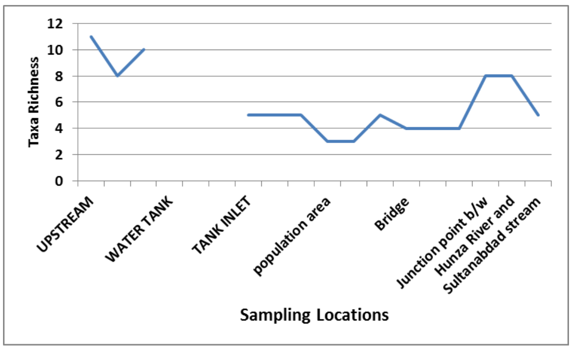

Fig. 3. Taxa richness of macro invertebrates in Sultanabad Stream at various locations.

The fig. 4 showed the sensitive group of macro invertebrates such as Ephemeroptera, Plecoptera and Trichoptera were higher at upstream and junction point. Diversity of macro invertebrates found in water. The more diversity in water, the better quality it is. These three families were considered least tolerant to organic pollution, thus, a sample with high EPT richness was considered indicative of good quality water. Abundance of Ephemeroptera (Mayflies) was higher at junction point and at upstream. Ephemeroptera (Mayflies) occupy a diverse range of freshwater habitats and were usually one of the best representatives of aquatic macroinvertebrates in any aquatic ecosystem. They showed moderate to slightly tolerant of pollution and usually require high dissolved oxygen concentration.

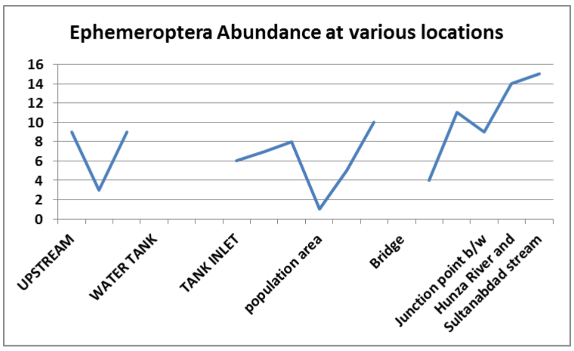

Fig. 4. The fig. shows whole abundance of Ephemeroptera in Stream.

The present study showed that the abundance of Trichoptera (Caddis flies) was higher at upstream as compare to other locations of the Stream (fig. 5). It is a diversified group with aquatic larvae that colonize most freshwater habitats, from high elevation to lowland running and standing waters (Ruffo and Stoch, 2005). So also, caddis flies are viewed as touchy to natural anxiety (Hall *et al*., 2006).

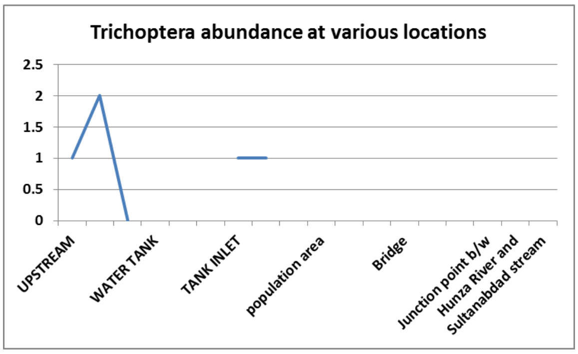

Fig. 5. The fig. shows the whole abundance of Trichoptera.

The present study showed that the total abundance of Plecoptera (Stoneflies) was higher at junction point as compared to other locations of the Stream and upstream showed the lower abundance of Plecoptera (fig. 6). Plecoptera have a high requirement for oxygen and are considered very sensitive to organic pollution (Mason, 2002).

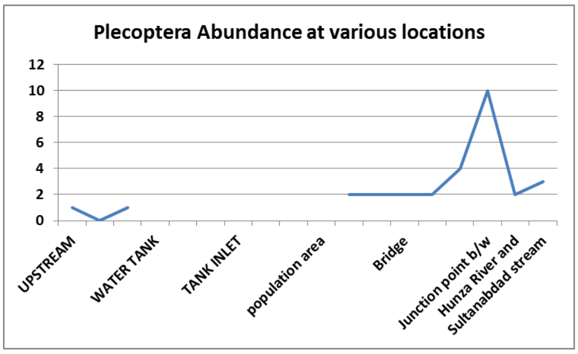

Fig. 6. The fig. shows the whole abundance of Plecoptera.

The present research showed that the total abundance of Diptera was higher at tank inlet as compare to other parts of the Stream (fig. 7). Their dominance may therefore represent very poor water quality. Conversely, it is possible that the Chironomidae species present have a higher sensitivity to organic pollution (Raunio *et al*., 2007).Their abundance at upstream were low that indicated no organic pollution presence at upstream.

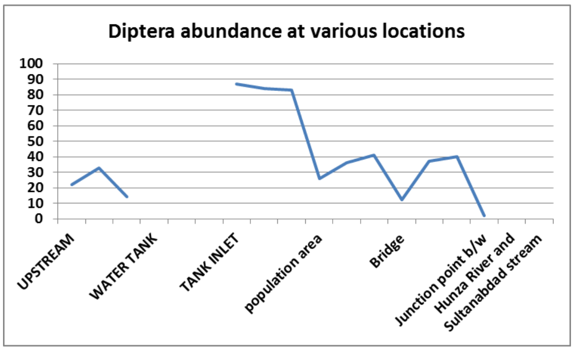

Fig. 7. The fig. shows the whole abundance of Diptera (dominated by Chironomidae) of Stream.

Physicochemical properties at various locations of the stream

The result of overall mean physio-chemical parameters of the stream were like alkaline pH (7.4), low temperature (8.9), high DO (10 mg/l), low EC (467 uS/cm), low nitrite (0.88 mg/l), low nitrate (8.8 mg/l) and low TDS (284.4 mg/l).

Dissolved oxygen (DO) is the measurement of the amount of gaseous oxygen dissolved in an aqueous solution. The mean highest DO was observed at the upstream was 10.8 mg/l while the lowest was 9.400 mg/l at bridge and at junction point that was 9.6667 mg/l. For a river to sustain aquatic life, it should be 6-8 mg/L. The six sampling sites have DO level above maximum which indicated that the stream was capable of supplying enough oxygen to sustain aquatic life.

pH values differed significantly with respect to various locations, highest was observed at upstream (8.19mg/l) and lowest at junction point (6.9mg/l) (fig. 9).

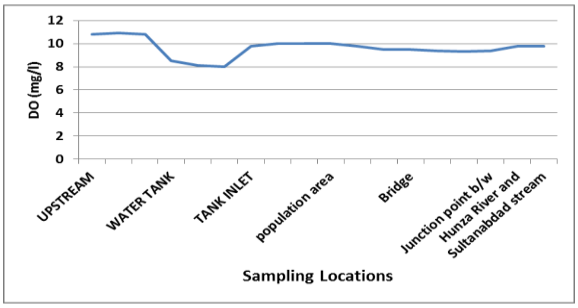

Fig. 8. Mean Dissolved Oxygen (DO) of Stream at different location.

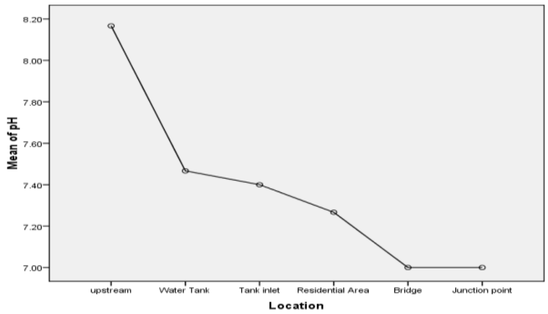

Fig. 9. Mean pH of the Stream at different locations.

The electrical conductivity is a measure to the capacity of water to conduct electrical current, it is directly related to the concentration of salts dissolved in water, and therefore to the Total Dissolved Solids (TDS). Salts dissolve into positively charged ions and negatively charged ions, which conduct electricity. The conductivity of stream ranges from 150-1500 µmhos/cm which is suitable for macro invertebrates (APHA, 1992).Above this level macro invertebrates cannot survive, Electrical conductivity (EC) of the Stream ranges from 457-480uS/cm, highest at residential area and lowest at upstream (fig. 10).

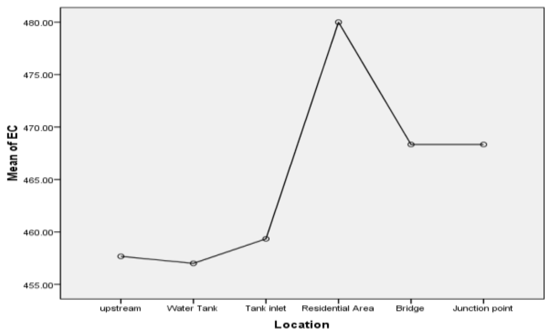

Fig. 10. Mean Electrical Conductivity of the Stream at different locations.

The highest level of nitrate was found at residential area, bridge and junction point while lowest level was found at upstream and tank inlet, because there was no any human activities were occurred at these sites (fig. 11).

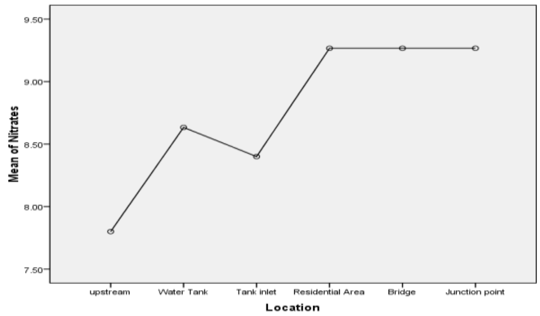

Fig. 11. Mean Nitrate of the Stream at different location.

The highest level of nitrites was found at bridge and junction point area while the lowest nitrite level was at upstream, water tank and tank inlet because there was no any anthropogenic activities occurred (fig. 12).

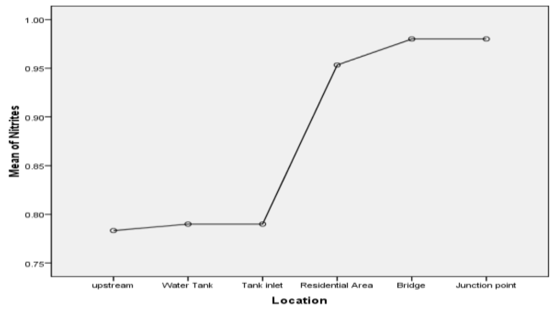

Fig. 12. Mean Nitrite of the Stream at different locations.

TDS is a measure of the dissolved matters such as salts, organic matter, minerals, etc. The highest level of TDS was observed on the tank inlet, residential area, bridge and at junction point due to anthropogenic activities. While the lowest level was observed at the upstream and water tank (fig. 13). As the maximum contamination level of a freshwater is 500 mg/L. When the TDS level exceeds 1000 mg/L it is generally considered unfit for human consumption. The six sampling sites were observed to have TDS below the maximum contamination level so it is safe for drinking.

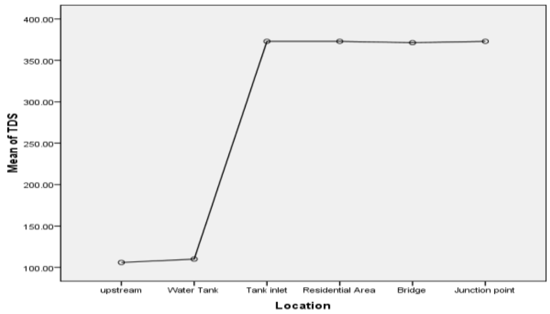

Fig. 13. Mean TDS of the Stream at different locations.

Mean highest temperature level was observed in the water tank and in junction point area while the coldest is observed in the upstream area (fig. 14). Water temperature affects streams indirectly by influencing the DO concentrations. Warm water can hold less oxygen in solution than cold water, that's why it is necessary to measure temperature of stream which indirectly effect macro invertebrates.

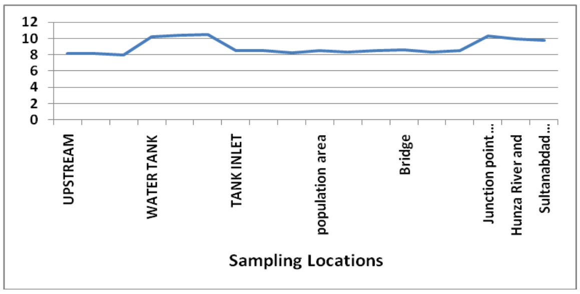

Fig. 14. Mean Temperature of the Stream at different locations.

Result of overall physio-chemical parameters of the stream were such as alkaline pH (mean 7.4), low temperature (mean 8.9 ^{o}C), low TDS (mean 284.4 mg/l), low EC (mean 467 µS/cm), high DO (mean 10 mg/l), low nitrite (mean 0.88 mg/l) and nitrate (mean 8.8 mg/l).

Conclusion

Sensitive group of macro invertebrates such as Plecoptera, Trichoptera and Ephemeroptera abundance were higher in junction point and in upstream as compare to other sites of the Stream indicating better ecological health. Diptera family (Chironomidae) was dominant at residential area of the stream indicating poor water quality or ecological health at that certain location. Physio-chemical parameters of the Stream such as alkaline pH, low temperature, high DO, low TDS, low EC and low nitrites and nitrates indicating fairly good water quality in general and upstream in particular.

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