Full Length Research Paper

Influence of water quality on the diversity and distribution of macro-invertebrates in highland stream, Northern Ethiopia

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The diversity of tropical aquatic ecosystems is severely threatened by anthropogenic activities. What is more, the continuum of most of the tropical river is interrupted by several man-made activities contributing to adverse effects which hamper the provision of good quality water. This study was conducted to assess the influence of water quality on the diversity and distribution of macroinvertebrates in Highland stream of Tigray region. A total of 42 taxa of benthic macroinvertebrates were recorded. Among which Trichoptera (31%) and Ephemeroptera (16%) were the dominant taxa. Furthermore, species diversity is positively correlated with water quality. Generally, low macroinvertebrate diversity was observed in the stream section with overall water degradation and anthropogenic disturbance. Thus, man-made activities may have caused changes among the physicochemical parameters which led to depletion of benthic macroinvertebrate biota in Illala stream. Thus, we recommend that effluent from the town should be carefully managed.

Key words: Macroinvertebrates, water quality, highland stream, pollution.

INTRODUCTION

Much of the ecosystem functioning and biodiversity in running water is explained by benthic macroinvertebrates because they serve as an important contributors in detritus processing, animal-microbial interaction and energy transfer to the consumers at higher trophic levels (Allan and Flecker, 199; Allan 1995, Wallace and Webster, 1996). Furthermore, there is entwining relationship between water quality streams and macroinvertebrate diversity. Macroinvertebrates are heterogenic collections of various evolutionary taxa where their biotic and diversity indices are used to determine water quality and pollution changes in the streams.

It is argued that the physical and chemical condition of many streams in tropical countries is deteriorating as a result of human population explosions, changes in land use, intensified agricultural practices and increased industrialization, all of which cause changes to natural flow regimes directly or indirectly (Pringle et al., 2000; Wishart et al., 2000). In different parts of the world, streams and rivers are the major sources of water in satisfying human needs. Such uses are clearly manifested and magnified in developing countries where streams and rivers are the main supply of water for domestic uses, agriculture, transport, industries, power production and recreation. Their importance becomes more pronounced in developing countries, especially, in rural areas where they are major sources of drinking water without any form of treatment. Contrary to urban areas of most developing countries, they serve as receivers of untreated industrial, municipal, clinical, and other types of liquid wastes, dumping sites of solid wastes with different constituents from residential
areas and are sites for open air urination. The situation is not different in Ethiopia where organic pollution from residential, agricultural and industries are dumped into rivers and streams (Zinabu and Elias, 1989). Furthermore, there is a pressure to use these water resources with maximum effort to feed the fast growing population and improve the standard of living of citizens. Thus, in order to use this huge water resource for the benefit of the citizen in sustainable manner, developing easily applicable biological monitoring system for assessment of aquatic ecosystems is very crucial. Moreover, little of Macroinvertebrate diversity in Ethiopia in general and Tigray in particular is known. Harrison and Hynes (1988) described the distribution of benthic fauna in the mountain streams and rivers of Ethiopia. Besides, Seyoum et al. (2003) characterized the wastewater and downstream pollution profiles of Mojo River in the rift valley portion of Ethiopia. However, these are studies with sporadic sampling of small section of streams. Thus, there is a need to develop identification keys and characterization of macroinvertebrate communities based on the countries biota after individual studies are conducted from the different water bodies of the region. Apart from this, it is a well-established fact that the activity in the watershed affects the quality of water resource in which humans and animals within the watershed depends on. Thus, one would consider streams and rivers as mirrors of the landscape reflecting the 'health' of their catchments.

A study by Tesfaye (1988) indicated that benthic macroinvertebrate composition and abundance varies along Kebena River as pollution gradient increases. This clearly indicates that macroinvertebrates in Ethiopia could be good evidence for developing bio-assessment methodology especially, using macroinvertebrate as indicators. Furthermore, most of the European researchers use non-systematic units such as fish, macrophytes, phytoplankton and diatoms for regular observations and determination of ecological status of the streams (De Pauw et al., 1992). Among which the most frequently used by communities to determine the water quality in streams is the macroinvertebrates. However, such study is lacking in Tigray region of Northern Ethiopia. Thus, this study was conducted to assess the influence of water quality on the diversity and distribution of macroinvertebrates in Highland stream of Tigray region.

MATERIALS AND METHODS

Description of the study site

The study area is located in Mekelle Town (13° 32’ N Latitude and 39° 33’ 8” E Longitude) (Figure 1). Mekelle is the capital city of the Tigray national Regional state in northern Ethiopia. The stream is an intermittent stream that passes through the Southwestern portion of Mekelle...
Table 1. The most dominant order of macroinvertebrates in Illala stream.

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Order</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trichoptera</td>
<td>Rhyacophilidae</td>
<td>Plecoptera</td>
<td>Perlidae</td>
</tr>
<tr>
<td></td>
<td>Glossosomatidae</td>
<td></td>
<td>Nemouridae</td>
</tr>
<tr>
<td></td>
<td>Hydropsychidae</td>
<td></td>
<td>Leuctridae</td>
</tr>
<tr>
<td></td>
<td>Polycentropodidae</td>
<td></td>
<td>Lumbricidae</td>
</tr>
<tr>
<td></td>
<td>Psychomyiidae</td>
<td></td>
<td>Tubificidae</td>
</tr>
<tr>
<td>Limnephilidae</td>
<td>Oligochaeta</td>
<td></td>
<td>Lumbriculidae</td>
</tr>
<tr>
<td>Leptoceriidae</td>
<td>Sericostomatidae</td>
<td></td>
<td>Pediciidae</td>
</tr>
<tr>
<td>Beraeidae</td>
<td>Odontoceridae</td>
<td></td>
<td>Chironomidae</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td>Baetidae</td>
<td></td>
<td>Simuliiidae</td>
</tr>
<tr>
<td></td>
<td>Heptageniidae</td>
<td></td>
<td>Athericidae</td>
</tr>
<tr>
<td></td>
<td>Leptophilebiidae</td>
<td></td>
<td>Empididae</td>
</tr>
<tr>
<td></td>
<td>Ephemericidae</td>
<td></td>
<td>Limoniidae</td>
</tr>
<tr>
<td></td>
<td>Ephemerellidae</td>
<td></td>
<td>Tabanidae</td>
</tr>
<tr>
<td></td>
<td>Dytiscidae</td>
<td></td>
<td>Tipulidae</td>
</tr>
<tr>
<td></td>
<td>notonectidae</td>
<td></td>
<td>Culicidae</td>
</tr>
</tbody>
</table>

city. The stream provides several services on which the people depend on the stream running past the town for household consumption, irrigation and carwash along its gradient from the head water as it passes through the city and joins the Romanat River. Furthermore, people use the stream water to wash their clothes in the stream and as source of water for their livestock drinking as well.

**Data collection**

Five sampling sites were selected along the Illala stream that pass through the town Mekelle (sampling site 1 (above the city, less anthropogenic impact and no much settlement) sites 2, 3, 4 and 5 are stream sections that lie within the town's vicinity but with different characteristics; site 2 is characterized with a lot of water obtractions for TARI, a nearby tissue culture and site 3 are areas where there are lots of human activities like the washing of cars and motorcycles. Site 4 is also characterized as the site having water abstraction for irrigation and used as a dumping site for waste discharged from downtown Awash Park. Site 5 is characterized by less human impact surrounded by farmlands.

Both (semi) quantitative sampling Multi-Habitat Sampling approach (MHS) of 25 x 25 cm area was used and a total of 20 sampling units per sampling sites were taken (thus making a total sample of 100) and sample per sites were combined and preserved in 4% formaldehyde for later identification in the laboratory. During field sampling, a rapid field assessment method for sensory features, chemical processes and composition of biota in the stream were assessed using the Austrian screening protocol (Appendix 1) and samples were brought to the biology laboratory, sieved and sorted from sub sample sediments of known areas.

Macroinvertebrate communities along the highland stream of Illala were sampled during July 2011 to June, 2012 at the five stations using D-Frame Dip Net and Multi-Habitat Sampling approach (MHS) used in order to include all possible microhabitats at each sampling stations. In some areas with the presence of large stones, these were first picked out and washed into the net to remove pupae and other attached macroinvertebrates. In addition, macroinvertebrate samples were separated from the macrophytes and the sediment using sieves of different mesh size at Biology department, Mekelle University, Ethiopia. The macroinvertebrates were sorted, identified to the lowest possible taxon (genus or families where possible to species level) and counted under a stereomicroscope. Furthermore, at the time of sampling water temperature (°C), pH, dissolved oxygen (DO mgL⁻¹) and electrical conductivity (EC) (μScm⁻¹) were measured in the field using portable equipments.

**Data analysis**

All data collected were subjected to statistical analysis appropriate for the multimetric approach used to express the ecological quality of the water body as a number
Figure 2. Composition of insect orders in Illala stream.

Figure 3. Category to which the individual macroinvertebrates belong.

using:

1. Richness measures (Number of Ephemeroptera taxa and total taxa),
2. Composition measures (like % Ephemeroptera taxa, % EP abundance, % Oligochaeta + Diptera taxa and % shredder and grazer and
3. Diversity measures (Diversity and species evenness).

Thus, this study is restricted to indices focused on the determination of water quality like the Family Biotic Index (Hilsenhoff, 1975), that is, number of Ephemeroptera,
Table 2. Expected and observed values of dissolved oxygen (concentration and saturation) among pre-classified classes.

<table>
<thead>
<tr>
<th>Quality class</th>
<th>Expected values**</th>
<th>Observed values**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DO (mg/L)</td>
<td>DO saturation (%)</td>
</tr>
<tr>
<td>I 8 or more</td>
<td>95-110</td>
<td>9.5</td>
</tr>
<tr>
<td>II &gt;6</td>
<td>70-125</td>
<td>9.79</td>
</tr>
<tr>
<td>III 4 or less</td>
<td>50-150</td>
<td>8.3</td>
</tr>
<tr>
<td>IV 2 to 4</td>
<td>25-200</td>
<td>6.78</td>
</tr>
<tr>
<td>V &lt;1</td>
<td>&lt;10 (deficit)</td>
<td>9.1</td>
</tr>
</tbody>
</table>

** The expected values are from Moog and Sharma (2005) for different quality classes and observed values are average values taken for the stream sections we measure in-situ.

Plecoptera and Trichoptera (EPT %) taxa, number of EPT/Chironomid (EPT/Chr %) and of Shannon and Weaver Diversity Indices (SWDI) which is calculated as:

\[ H = - \sum_{p} p \times \ln p \]

Where:
\( p \) = Relative abundance
\( \ln p \) = Natural logarithm of relative abundance.

Owing to the taxonomic difficulties, not all species were identified to species level, thus, taxa richness has been treated as synonymous as species richness in this study.

RESULTS AND DISCUSSION

Macroinvertebrate composition and abundance

A total of 2969 individuals composed of 8 orders of insects and 4 orders of non-insects were collected during the study time. The most dominant orders of taxa belong to 30 insect families and 3 families of the order Oligochaeta (Table 1 and Figure 2). Among the insect orders, Trichoptera and Diptera are the most dominant with 31 and 28% of the macroinvertebrate community followed by Ephemeroptera with 16% of the total taxa of insect order (Figure 2). Furthermore, it is found out that more than 53% of the individuals collected belong to insect orders (Figure 3) while less than 47% belong to the non-insect order like Gastropoda and Oligochaetae among others. Among the non-insect order, Oligochaetae and Gastropoda are dominant with 37.50% of total composition of non-insect orders. However, Planariidae and Hydrarcarina have the percentage composition of 12.5% each.

The different stream sections were pre-classified using expected values for dissolved oxygen (Table 2). Accordingly, sampling site 1 falls under quality class I (with 98 mg/L DO) whereas stream sections 2, 3 and 4 falls under quality class II with DO given (Table 2).

Changes in physicochemical structure also affected the diversity of species at each sampling stations. Furthermore, the great majority of the existing taxa at 1st and 2nd sampling stations have not been observed at 3rd and 4th sampling stations. As a result of the water quality assessment using biotic indices (Table 4), the 3rd and 4th sampling stations were determined as the polluted part of the stream, fitting in exactly with the water quality classification done according to the physicochemical parameters (Table 2). Furthermore, diversity indices values of these sampling stations (that is, 3rd and 4th) are lower than either of the other sampling stations (that is, 1 and 2). This clearly supports the data from dissolved oxygen (DO) and oxygen saturation (%) given (Table 2).

In this study, fluctuation of pH (Figure 4) between reference sites (mean value of 7.9) and impacted site was not statistically significant (T-test, n=20 and p <0.05). Thus, the influence of pH on the evaluation of the quality status of sampling sites can be excluded which means that these parameters were not selected to support the classification of quality classes. However, it is known that the pH is an important variable that can influence chemical and biological processes in the stream water (Resh, 1995; Rosenberg and Resh, 1993; Dow and...
Table 4. Comparison of predicted response of different Biometric index and response calculated based on data from Illala stream.

<table>
<thead>
<tr>
<th>Biometric index</th>
<th>Predicted response</th>
<th>Responses met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of taxa</td>
<td>Decrease</td>
<td>Variable</td>
</tr>
<tr>
<td>Number of Ephemeroptera taxa</td>
<td>Decrease</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Ephemeroptera</td>
<td>Decrease</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Chironomidae</td>
<td>Decrease</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Coleoptera taxa</td>
<td>Decrease</td>
<td>Variable</td>
</tr>
<tr>
<td>Number of Intolerant Taxa</td>
<td>Decrease</td>
<td>Yes</td>
</tr>
<tr>
<td>Shannon-Wiener index</td>
<td>Decrease</td>
<td>Yes</td>
</tr>
<tr>
<td>% Trichoptera</td>
<td>Decrease</td>
<td>Yes</td>
</tr>
<tr>
<td>% Ephemeroptera</td>
<td>Decrease</td>
<td>Yes</td>
</tr>
<tr>
<td>% Ephemeroptera</td>
<td>Decrease</td>
<td>Yes</td>
</tr>
<tr>
<td>% Diptera taxa</td>
<td>Increase</td>
<td>Yes</td>
</tr>
<tr>
<td>% Tolerant organisms</td>
<td>Increase</td>
<td>Yes</td>
</tr>
<tr>
<td>% Odonata</td>
<td>Increase</td>
<td>Yes</td>
</tr>
<tr>
<td>% Diptera</td>
<td>Increase</td>
<td>Yes</td>
</tr>
<tr>
<td>% Red Chironomids</td>
<td>Increase</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Zampella, 2000). Besides, it is reported that variations in pH within 24 h time can be caused by photosynthesis and respiration cycles of algae in eutrophic waters (Hawkins, 1978).

The water temperature fluctuation during the sampling time in all sampling site was insignificant (Mean = 23.78, p< 0.05 and n= 5). As seen from Figure 4, the values under reference condition were lower (mean 22.9°C) than at impacted sites 3 and 4 (mean = 25°C). This observation may be due to the fact that reference site is located in the head water section of the river having relatively more shading and such a result have been reported by Kalyoncu and Zeybek (2011).

As indicated in Table 2 and Figure 5, sites which were classified as quality class II (based on DO and O₂%) accounts for high levels of conductivity (with 4.8 dS/m and 5.4 dS/m at sampling sites 4 and 5 respectively). All sites under this quality class were located downstream of
high human activity (downtown Awash park and different garages in the area), which uses the streams as main waste (effluent) dumping site. On the contrary, the reference sites have relatively low conductivity reflecting the normal ions present in the water (mean 4.6) (Figure 5). Therefore, in a direct comparison with an existing reference site or in the case of stable basic natural conductivity conditions, conductivity could be used as a good discriminating parameter for quality classes.

In this study, conductivity can excellently discriminate the reference sites from impacted sites (Figure 5). This is in agreement with reports by Kalyoncu and Zeybek (2011). Furthermore, it is argued elsewhere that conductivity can be influenced largely by geology since it is highly influenced by mineral salts (Kalyoncu et al., 2009a, b).

However, an increase in conductivity possibly occurs when additional wastes containing ions enter the stream section (Kalyoncu et al., 2008a). Thus, it is highly probable that the increase in conductivity in the stream from sampling site 1 down to sampling 4 is due to the additional waste from residence as well as other anthropogenic activities.

**Macro-invertebrate diversity and species richness**

We have calculated the diversity index for each sampling sites given and as indicated in Table 3, the species diversity increases with water quality (that is, the highest diversity is observed in the sampling site with a good water quality). This result is in line with Washington (1984). Besides, we have compared the different richness and composition measures with predicted response for each biometric index with calculated responses (each metric calculated based on data collected) and we found that a good correspondence (Table 4) between the both. This is in agreement with the generally accepted principle that macroinvertebrate community structure can be used as indicators of the condition of an aquatic system as stated in different literatures (Armitage et al., 1983; Friberg et al., 2006; Ortiz and Puig, 2007).

We further categorized the macroinvertebrate community into different feed groups using Moog's (1995) functional feeding groups (Figure 6). Overall, the macroinvertebrate community of Illala stream is highly dominated by grazers (43%) while the filter feeders are the least feeding groups.

**CONCLUSION**

In summary, the macroinvertebrate community of highland stream is dominated by grazers and there is a good correspondence between macroinvertebrate diversity and physicochemical water quality parameters. This study in the highland stream provides a preliminary assessment of what appears to be predominantly...
Anthropogenic impacts on macroinvertebrate communities. Generally, low macroinvertebrate diversity indicates an overall water degradation and anthropogenic disturbance effect throughout the stream section.

ACKNOWLEDGEMENTS

The Authors would like to extend their gratitude to Mr. Solomon Amare and Gebru Equar of the Department of Biology, Mekelle University, for their help in the field work of this research and also to NORAD project for the financial assistance through CNCS/MU-UMB/02/2011 given to Tsegazeabe H. Haileselasie.

REFERENCES


### Appendix 1. Decision support table used in field.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Water quality classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td><strong>Multiple choices possible</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sensory features</strong></td>
<td>To be ticked /counted if not in accordance with natural river type</td>
</tr>
<tr>
<td>Non natural turbidity, suspended solids</td>
<td>-</td>
</tr>
<tr>
<td>Non natural colour</td>
<td>-</td>
</tr>
<tr>
<td>Foam</td>
<td>-</td>
</tr>
<tr>
<td>Odour (water)</td>
<td>-</td>
</tr>
<tr>
<td>Waste dumping</td>
<td>-</td>
</tr>
<tr>
<td>Ferro-sulphide reduction-(water velocity &lt; 0, 25 m/s)</td>
<td></td>
</tr>
<tr>
<td>Mud reduced but with aerobic surface</td>
<td>-</td>
</tr>
<tr>
<td>Mud reduced but with anaerobic surface</td>
<td>-</td>
</tr>
<tr>
<td>Lower surface of stones (% cover black dots)</td>
<td>-</td>
</tr>
<tr>
<td>Upper and lower surface of stones (% cover black dots)</td>
<td>-</td>
</tr>
<tr>
<td>Ferro-sulphide reduction-(water velocity 0, 25 – 0, 75 m/s)</td>
<td></td>
</tr>
<tr>
<td>Mud reduced but with aerobic surface</td>
<td>-</td>
</tr>
<tr>
<td>Mud reduced but with anaerobic surface</td>
<td>-</td>
</tr>
<tr>
<td>Lower surface of stones (% cover black dots)</td>
<td>-</td>
</tr>
<tr>
<td>Upper and lower surface of stones (% cover black dots)</td>
<td>-</td>
</tr>
<tr>
<td>Ferro-sulphide reduction-(water velocity &gt; 0, 75 m/s)</td>
<td></td>
</tr>
<tr>
<td>Lower surface of stones (% cover black dots)</td>
<td>-</td>
</tr>
<tr>
<td>Upper and lower surface of stones (% cover black dots)</td>
<td>-</td>
</tr>
<tr>
<td>Bacteria, fungi and periphyton</td>
<td></td>
</tr>
<tr>
<td>Sewage fungi and bacteria (visible to the naked eye)</td>
<td>-</td>
</tr>
<tr>
<td>Sulphur bacteria (visible to the naked eye)</td>
<td>-</td>
</tr>
<tr>
<td>Clean water algae (for example, Chamaesiphon)</td>
<td>+++</td>
</tr>
<tr>
<td>Stones with algae vegetation (periphyton) in thin layer</td>
<td>++</td>
</tr>
<tr>
<td>% of thick significant layers of algae</td>
<td>&lt; 25%</td>
</tr>
<tr>
<td>Filamentous green algae</td>
<td>None to few</td>
</tr>
<tr>
<td>Algal bloom</td>
<td>-</td>
</tr>
</tbody>
</table>
## Appendix 1 Contd.

<table>
<thead>
<tr>
<th>Benthic macro-invertebrates</th>
<th>+++</th>
<th>+</th>
<th>-</th>
<th>-</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katharobic indicators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Syn-(Agapetus sp)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perlidae</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Plecoptera</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Epeorus assimilis</td>
<td></td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Philopotamus spp</td>
<td></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Odontocerum sp</td>
<td></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rhithrogena spp</td>
<td></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Heptageniidae</td>
<td></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lepidostomatidae</td>
<td></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potamanthus</td>
<td></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Simuliidae</td>
<td></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hydropsyche spp (medium to many)</td>
<td>-</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Prodiamesa olivacea</td>
<td>-</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Physa spp (medium to many)</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Potamopyrgus antipodarum (&gt; medium)</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Asellus aquaticus (more than naturally occurring)</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Leeches (more than naturally occurring)</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Chironomids with red colour</td>
<td>-</td>
<td>Very few</td>
<td>Few</td>
<td>Medium</td>
<td>+++Many*</td>
</tr>
<tr>
<td>Bezzia-group</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Psychodidae white</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Air-breathing animals, e.g. rat-tail maggots</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+++</td>
</tr>
<tr>
<td>Oligochaeta/Tubificidae (mud worms)</td>
<td>0 to few</td>
<td>Few</td>
<td>Few/medium</td>
<td>Medium/many</td>
<td>Many*</td>
</tr>
</tbody>
</table>

(* Abundance may decline to 0 if oxygen depletes).