WATER QUALITY AND WATER POLLUTION ASSESSMENT

[Photograph taken at a clean Lopo River (a branch and upstream of Langat River), Selangor]

[Photograph taken during sampling at downstream and polluted section of Langat River, Selangor].

[Photograph taken at a clean Selangor River, Selangor]

[Photograph shown the "worm carpet" at downstream and polluted section of Langat River, Selangor].

CHEMICAL METHODS

Water chemistry includes measures of a variety of elements and molecules dissolved or suspended in water. Some "chemical" measures are actually physical measures that indicate the presence of chemical features of water. For instance, conductivity is a physical measure (the ability of water to conduct an electrical current) that indicates the presence of dissolved chemicals (cations and anions) in water. Salts such as sodium chloride (NaCl, table salt) form ions (Na+ and Cl-) when dissolved in water, and it is these ions that allow a current of electricity to pass through the water.

Chemical measures commonly used in water quality field surveys are indicators of some form of pollution. They indicate some imbalance within the stream ecosystem. For instance, pH gives an indication of the acid/base balance of water, and low pH values are particularly useful for detecting acid mine drainage in many regions. However, some streams are naturally acidic, thus low pH is not necessarily indicative of acid mine drainage. In other systems pH may not detect acid mine drainage because of the natural buffering of the stream. Low pH is sometimes detected in small tributary streams draining abandoned mine lands, but pH in the mainstream below the mine site may be normal due to the

presence of alkalinity in the mainstream itself. Alkalinity is a measure of the water's ability to resist changes in pH, and results from the dissolution of calcium carbonate ($CaCO_3$) from limestone bedrock that is eroded during the natural process of weathering.

Some chemical indicators are specific for particular forms of pollution, but most indicate only that something is out of balance. For instance, low dissolved oxygen often results from the input of raw sewage, but low dissolved oxygen is also caused by the consumption of oxygen during reactions leading to the generation of acid mine drainage.

BIOLOGICAL METHODS

Macroinvertebrates as Bioindicator

- **Stream benthic macroinvertebrates are an important part of the community of life found in and around a stream.**

  Stream-bottom macroinvertebrates are a link in the aquatic food chain. In most streams, the energy stored by plants is available to animal life either in the form of leaves that fall in the water or in the form of algae that grows on the stream bottom. The algae and leaves are eaten by macroinvertebrates. The macroinvertebrates are a source of energy for larger animals such as fish, which in turn, are a source of energy for amphibians, birds, watersnakes, and even human beings.

- **Stream benthic macroinvertebrates differ in their sensitivity to water pollution.**

  Most stream-bottom macroinvertebrates cannot survive in polluted water. Others can survive or even thrive in polluted water. In a healthy stream, the stream-bottom community will include a variety of pollution-sensitive macroinvertebrates. In an unhealthy stream, there may be only a few types of nonsensitve and tolerant macroinvertebrates present.

- **Stream benthic macroinvertebrates provide information about the quality of a stream over long periods of time.**

  It may be difficult to identify stream pollution with water analysis, which can only provide information for the time of sampling. Even the presence of fish may not provide information about a pollution problem because fishes are mobile can move away to avoid polluted water and then return when conditions improve. However, most stream-bottom macroinvertebrates cannot escape and move to avoid pollution. A macroinvertebrate sample may thus provide information about pollution that is not present at the time of sample collection.

- **Stream benthic macroinvertebrates are relatively easy to collect.**

  Useful stream-bottom macroinvertebrate data are easy to collect without expensive equipment. The data obtained by macroinvertebrate sampling can serve to indicate the need for additional data collection, possibly including water analysis and fish sampling.

Biological Field Sampling

Samples were collected using a Hess sampler in larger streams, and a Surber sampler in smaller streams. Macroinvertebrates were removed from nets and placed in a labelled polythene container. Samples were preserved with 75% alcohol for transport to the laboratory. In tropical, it is advisable to preserve the samples with preservative. Macroinvertebrates were placed in white enamel pans and sorted from debris by hand.

Identification and Key

This key consists of pairs of opposite choices in form of dichotomous key. To use this key, start at the first number and read the two statements. Decide which statement best describes the organism and click on your choice. Repeat the procedure until the macroinvertebrate is identified. You can then click on the macroinvertebrate name and additional information concerning the identification, life history, and pollution sensitivity of the macroinvertebrate will be provided.

If you reach a point in the selection of descriptive statements at which neither of the statements apply, you can work your way back through the preceding pairs of statements and perhaps reconsider the choices. In some cases, the additional information about the individual macroinvertebrates will be helpful. In others, you will find that you are unable to identify the particular macroinvertebrate and you will have to identifiy it as "unknown" unless you can find an aquatic biologist or more information to help you with the identification.

Some macroinvertebrates (such as some caddisfly larva) will be found in a protective case of sand, small sticks, or other material. You may find it necessary to remove these cases in order to make an identification.

For some specimens, magnification with a hand lens will be needed to see the identification characteristics.

After you have made an identification you can return to the first page of the key to identify additional specimens. Note: drawings in the key are not to scale.

At the end of each taxa, it is indicated the sensitivity of the macroinvertebrate group:

- Very sensitive: The macroinvertebrate will immediately suffer, stress, die and disappear due to commencing of lowering water quality in slightly polluted water.
- Somewhat sensitive: The macroinvertebrate will present in low number individuals because of intermediate water quality in mild polluted water.
- Not sensitive/Tolerant: The macroinvertebrate will survive, dominant and high in number of individuals in very low water quality and severe polluted water.

Key of Identification

1. The macroinvertebrate has segmented (jointed) legs ----------goto-> 2

   The macroinvertebrate does not have segmented legs ----------goto->15

2. The macroinvertebrate has more than six legs ----------goto-> 3

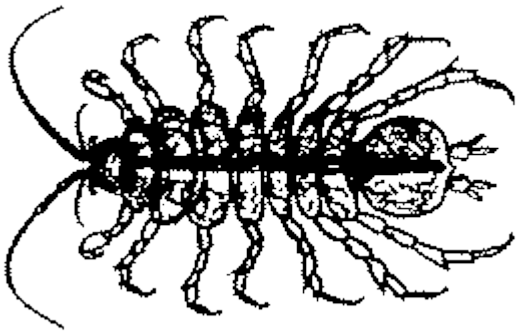
   The macroinvertebrate has six legs ----------goto-> 5

3. The macroinvertebrate has a body that is shrimp-like and moves ----goto-> 4

   quickly

   The macroinvertebrate has an armadillo-shaped body that is wider

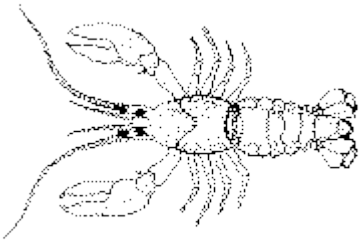
   than it is high and it walks slowly



   ----------> Sowbug (Crustaceae: Amphipoda: Isopoda) [Somewhat sensitive]

4. The macroinvertebrate has a body that is shrimp-like and

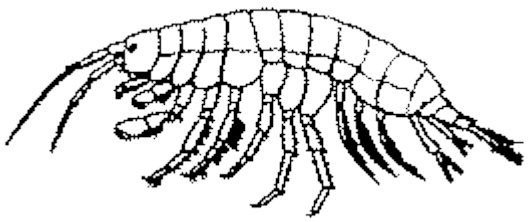
   has a fan shaped tail



   -------> Crayfish and Shrimps (Crustaceae: Amphipoda: Isopoda) [Somewhat sensitive]

   The macroinvertebrate has a shrimp-like body that is

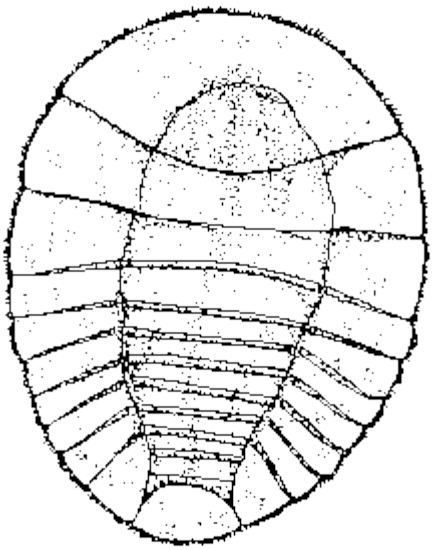
   higher than it is wide. It has no tail and it swims quickly



   --------------------> Scud (Crustaceae: Amphipoda) [Somewhat sensitive]

5. The macroinvertebrate has a body longer than it is wide ----------goto-> 6

The macroinvertebrate has a disk or oval shaped body



----------> Water Penny (Coleoptera: Psephenidae) [Very sensitive]

6. The macroinvertebrate has no tail or one tail consisting ----------goto-> 7

   of a single long filament

   The macroinvertebrate has two or three tails that are ----------goto->13

   either hairlike or broad (like oars)

7. The macroinvertebrate has an abdomen that is soft, not plated -----goto-> 8

The macroinvertebrate has an abdomen that is hard plated ----------goto->12

8. The macroinvertebrate has pairs of filaments that extend ----------goto-> 9

   from the abdomen

   The macroinvertebrate has no filaments extending from

   the sides of the abdomen

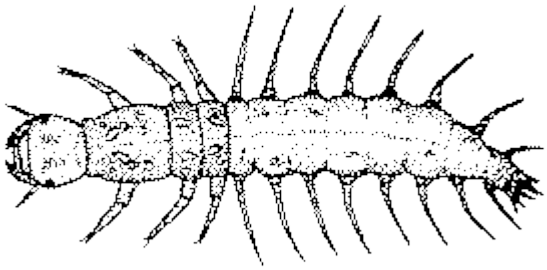
----------> Caddisfly (Trichoptera) [Very sensitive]

9. The macroinvertebrate has no gill tufts on abdomen ----------goto->10

   The macroinvertebrate has gills under the abdomen. It has

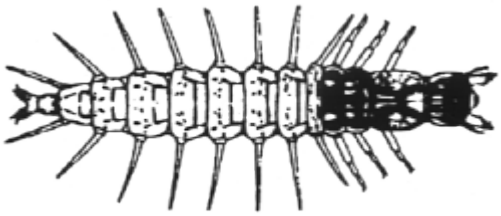
   one pair of hooks on the side of its tail, which is short

and forked



----------> Dobsonfly (Megaloptera: Corydalidae) [Very sensitive]

10.The macroinvertebrate has a short, forked tail



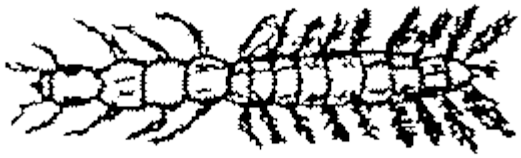
-------> Fishfly (Megaloptera: Corydalidae) [Somewhat sensitive]

The macroinvertebrate has an abdomen that ends in ----------goto->11

a long tail that is a filament or a point

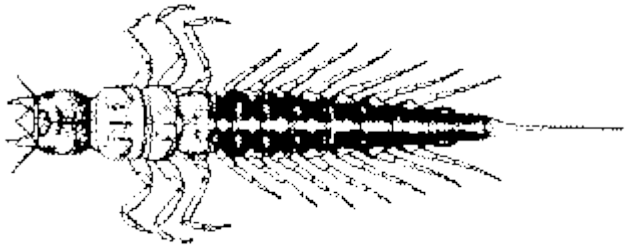
11.The macroinvertebrate has an abdomen that comes to a

point with four tiny hooks extending



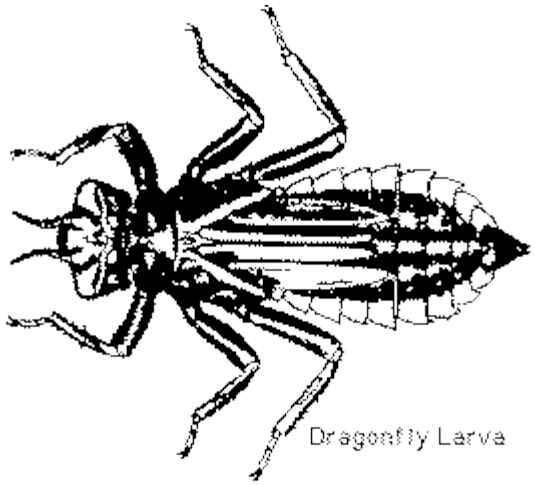
--------> Whirligig Beetle (Coleoptera: Gyrinidae) [Somewhat sensitive]

The macroinvertebrate has a single long tail filament



----------> Alderfly (Megaloptera: Sialidae) [Somewhat sensitive]

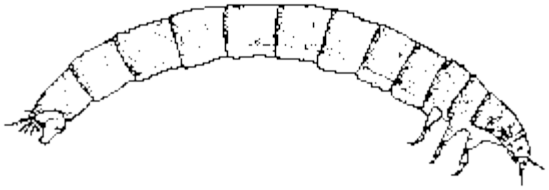
12.The macroinvertebrate has a wide abdomen and large eyes



------------------> Dragonfly (Odonata: Zygoptera) [Somewhat sensitive]

The macroinvertebrate has a body that is hard and stiff

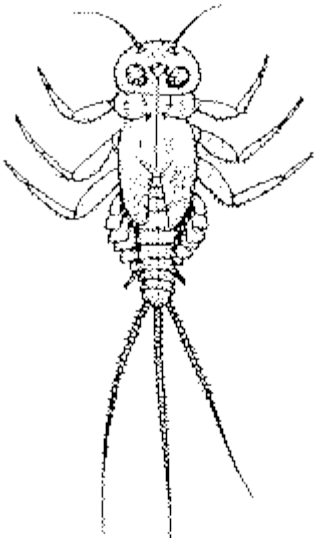
Its tail may have tiny hooks and filaments extending



--------> Riffle Beetle (Coleoptera: Elmidae) [Somewhat sensitive]

13.The macroinvertebrate has no gills on the abdomen -----------------goto->14

The macroinvertebrate has gills on the side of its abdomen

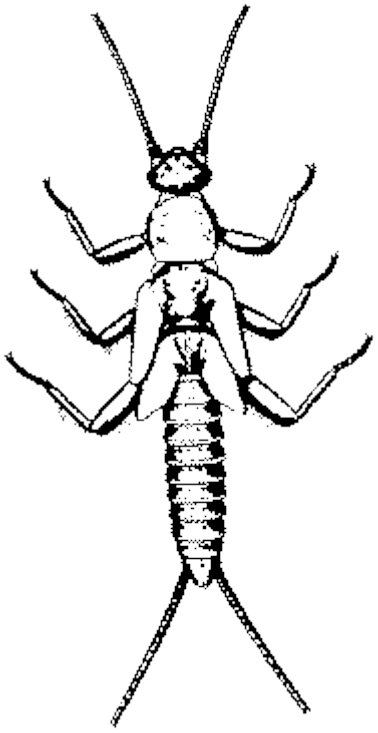


----------> Mayfly (Ephemeroptera) [Very sensitive]

14.The macroinvertebrate has three broad tails

----------> Damselfly (Odonata: Zygoptera) [Somewhat sensitive]

The macroinvertebrate has two hairlike tails



----------> Stonefly (Plecoptera) [Very sensitive]

15.The macroinvertebrate does not have a distinct head ----------goto->16

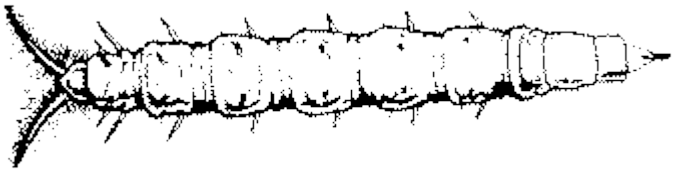
The macroinvertebrate has a distinct head ----------goto->20

16.The macroinvertebrate has no legs or leg-like appendages ----------goto->17

It does not have a head

The macroinvertebrate has legs or leg-like appendages

It does not have a head



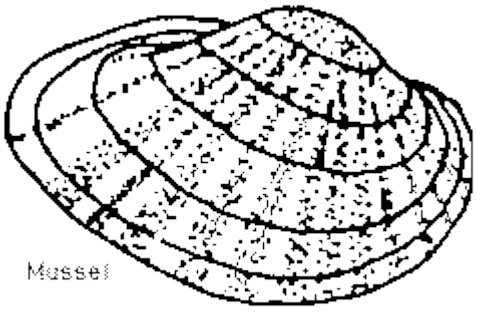
----------> Watersnipe Fly [Somewhat sensitive]

17. The macroinvertebrate has a body with hard shell(s) ----------goto->18

The macroinvertebrate has a body with no hard shell ----------goto->22

18. The macroinvertebrate has a body that is enclosed within

two hinged shells



----------> Bivalve Mollusc (Mollusca: Bivalvia) [Somewhat sensitive]

The macroinvertebrate has a spiral or coil shaped shell ----------goto->19

19.The macroinvertebrate has a plate-like cover over the opening

which is on the right hand side

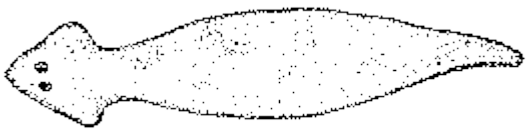
----------> Gilled Snail (Mollusca: Gastropoda) [Very sensitive]

The macroinvertebrate has no cover over the opening which

is on the left hand side

----------> Lunged Snail (Mollusca: Gastropoda) [Not sensitive/Tolerant]

20.The macroinvertebrate does not have any legs or leg-like appendages



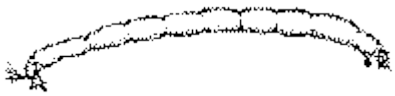
----------> Planarian (Turbellaria) [Very sensitive]

The macroinvertebrate has one or more tiny leg-like appendages ----goto->21

21.The macroinvertebrate has a body that widens at the back end

---------> Blackfly Larva (Diptera: Simuliidae) [Very sensitive]

The macroinvertebrate is the same width at both ends of the body



------> Midgefly (Diptera: Chironimidae) [Not sensitive/Tolerent]

22.The macroinvertebrate has an unsegmented body that is flat

It usually has eye spots

----------> Planarian (Turbellaria) [Very sensitive]

The macroinvertebrate has a segmented body ----------goto->23

23.The macroinvertebrate has a soft, plump, caterpillar-like body

----------> Cranefly (Diptera: Tipulidae) [Somewhat sensitive]

The macroinvertebrate has a worm-like body ----------goto->24

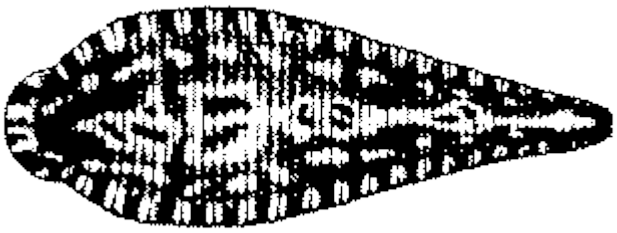
24.The macroinvertebrate has a long, segmented worm-like or

thread-like body

-------> Aquatic Worm (Oligochaeta: Tubificidae) [Not sensitive/Tolerant]

The macroinvertebrate has a segmented body with suckers at

each end



----------> Leech (Hirudinea) [Not sensitive/Tolerant]

Macroinvertebrates Sensitive to Water Pollution
Macroinvertebrates Somewhat Sensitive to Water Pollution
Macroinvertebrates Tolerant to Water Pollution

Enumeration and Data Analysis

Benthic macroinvertebrate densities were reported as the total number of organisms per square meter of stream bottom. Additionally, the number of mayflies, stoneflies, caddisflies, beetles, midges, all true flies, crustaceans, worms, and mollusks was reported. The total number of identifiable kinds of organisms is reported as richness. The Shannon index was used as a diversity index. The EPT index, a measure of the "quality" of the invertebrate community, was calculated as the number of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) divided by the total number of midges.

Example invertebrate indicators of specific impairment types

- Nutrient enrichment
  - increased ratio of aquatic worms (oligochaetes) to aquatic insects.
  - increased ratio of midges (chironomids) to other aquatic insects.
  - increase of herbivorous mayflies (ephemeropterans) and midges.
- Low dissolved oxygen
  - increased ratio of aquatic worms to aquatic insects.
  - increased ratio of midges to other aquatic insects.
- Contamination by heavy metals
  - increased ratio of aquatic worms to aquatic insects.
  - increased ratio of midges to other aquatic insects.
  - increased abundance of water bugs and water beetles.
  - increased ratio of predators to herbivores and detrivores.
- Sedimentation
  - decrease in mayflies and midges.
- Low pH
  - loss of snails, clams, mussels, daphnids, mayflies, midges.
- Temperature
  - Releases of heated effluents tend to reduce community richness.

(source: Adamus and Brandt, 1990)

WATER QUALITY AND BIOINDICATOR WEBSITES

- Biological Indicators of Watershed Health.
- The Stream Study.
- River Ouzel Water Quality (UK).
- Methods for Collecting Benthic Invertebrate Samples as Part of the National Water-Quality Assessment Program.
- Biological Monitoring.
- Water Quality.
- Water Quality Laboratory (Iowa).
- Wetland Insect Populations as Biological Indicators: Evaluation of a wetland mitigation monitoring tool.
- Studies on the Use of Vertebrates as Bioindicators for Environmental Pollution Monitoring.
- Biological Indicators.
- Measuring River Qualities.
- Biomonitoring of Streams and Rivers at W.K. Kellogg Biological Station.
- Monitoring of the Aquatic Environment: Vermont Department of Environmental Conservation.
- Biological Stream Assessment: Water Watch Biological Monitoring Procedures.
- Pollutech Enviroquatics.
- Australian Water Quality Centre.
- International Association on Water Quality (IAWQ).

- U.S. Environmental Protection Agency (USEPA).
- Environmental Monitoring: Water Monitoring.
- Water - How good is it?.
- Program of the USGS in Texas.
- Water Quality Index.
- Water Quality Index.
- Field Manual for Water Quality Sampling.
- ADAPTIVE SHORT-TERM WATER QUALITY FORECASTS USING REMOTE SENSING AND GIS.
- ENVIRONMENT AND HEALTH PROTECTION. SAFETY.
- Water Quality Taxonomy.

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