Pesticides

What are they?

Pesticides are chemical substances (or mixtures of substances) used to control the growth of insects, pathogens and weeds. They play an important part in the economic production of many agricultural commodities, in insect and weed control in urban areas and in the control of diseases such as malaria. By law, all pesticides are thoroughly screened for health and environmental effects before registration.

How do they behave in the aquatic environment?

Pesticides get into waterways from direct use in the waterway - for example, to control mosquitoes or water weeds - or from land-based applications, aerial drift, or in runoff waters. Leaching through soils can lead to some pesticides being found in groundwater supplies.

Pesticides remain active in the environment for some time after they have been used. This is referred to as the **persistence** of the pesticide. In aquatic environments the persistence of different pesticides varies widely from days to years, depending upon the type of pesticide. Each pesticide's persistence is also influenced by factors such as temperature, light, acidity and salinity. Most insecticides in current use are relatively non-persistent (in contrast to earlier insecticides), but some of the herbicides can persist for several months or longer.

Many pesticides are very soluble in water while others are less soluble and are more likely to be found attached to suspended soil particles or sediments. Some persistent pesticides tend to accumulate in animal tissues.

Some insecticides are highly toxic to aquatic animals. Effects can be lethal, although it is worth nothing that the presence of pesticide residues in fish sampled following a fish mortality incident is not conclusive evidence that the pesticide was the cause of death. Other insecticides can have more subtle, sub-lethal effects on aquatic animals, such as a reduction in vigour or reproductive ability.

Herbicides are generally considered to have low toxicity to aquatic animals, but they may have adverse, chronic effects. They may also impair growth of some aquatic plants and algae.

How do you collect a sample to test for pesticides?

It is recommended that **waterwatchers** contact their closest laboratory for advice on collecting and analysing water for evidence of pesticides.

Suggestions about testing procedures

There are many issues to be considered when monitoring for pesticides, including where to sample, what to sample and what pesticides to measure. No single test can indicate what pesticides are present in a sample. The CSIRO has recently developed field tests for some specific pesticides using Elisa kits. In general, however, pesticide analyses must be carried out by specialised laboratories.

Specially treated bottles are required for sample collection and there is no simple way for the community member to test for the presence of pesticides. Contact any private water testing laboratory and arrange for them to do your testing for you. Be aware that there will be a cost involved. Get further advice from your local Waterwatch co-ordinator.

Interpreting your results

Recommended upper limits for concentrations of a number of pesticides are provided in the ANZECC (1992) guidelines for ecosystems protection, drinking water and agricultural use.

Examples of pesticide guideline values

Pesticide	Raw water for drinking (maximum concentration μg/L)	Unfiltered water for fresh and salt aquatic systems (maximum concentration μg/L)
Acephate	20.0	
Aldrin	1.0	0.01
Carbaryl	60.0	
Chlordane	6.0	0.004
Chlorpyrifos	2.0	0.001
DDT	3.0	0.1
Demeton	30.0	0.1
Dieldrin	1.0	0.002
Dicofol	100.0	
Dimethoate	100.0	
Disulfoton	6.0	
Endosulfan	40.0	0.01
Endrin	1.0	0.003
Fenvalerate	40.0	
Formothion	100.0	
Glyphosate	200.0	
Heptachlor	3.0	0.01
Lindane	10.0	0.03
Methomyl	60.0	
Monocrotophos	2.0	
Omethoate	0.4	
Parathion	30.0	0.004
Parathion-methyl	6.0	
Permethrin	300.0	
Profenofos	0.6	
Sulprofos	20.0	
Thiometon	20.0	
2,4-D	100.0	

Heavy metals

What are they?

Heavy metals is a name applied to a group of metals which are often associated with pollution and toxicity. Examples of these metals include copper, zinc, cadmium, lead and mercury. Although trace amounts of some heavy metals such as copper and zinc are essential nutrients for the growth of plants and animals, excessive amounts of these metals cause severe disease problems.

Some industrial processes use heavy metals. In agriculture, copper and zinc are sometimes applied in small amounts as fertilisers while cadmium and zinc may occur as impurities in some phosphatic fertilisers. Copper is also used in several pesticide formulations.

How do they have in the aquatic environment?

- **Heavy metals are found naturally in many aquatic environments**

  They are a result of rocks weathering in the catchment. Natural concentrations in mineral-rich areas can be quite high. Heavy metals are most often attached to suspended soil particles in the water and with bottom sediments. Concentrations of metals dissolved in water are generally very low.

- **Many heavy metals are very toxic to aquatic animals**

  Even those essential for growth can have adverse effects at only slightly higher than normal concentrations. The ability of aquatic animals to absorb heavy metals and the degree of toxicity to those animals can be influenced by several factors. These include the chemical form of the metal, the presence of other metals, salinity levels, temperature and dissolved oxygen levels. Some heavy metals can accumulate in the tissues of aquatic animals.

- **Industrial and mining activities are the major sources of heavy metal contamination in Australian waters**

  Discharge to waterways often occur when mines are being drained.

  Other sources of heavy metal contamination can be from stormwater runoff from urban areas.

How do you collect a sample to test for heavy metals?

It is recommended that **waterwatchers** contact their closest laboratory for advice on testing for heavy metals.

Suggestions about testing procedures

There are many issues to be considered when monitoring for heavy metals, including where to sample, what to sample and what heavy metals to look for. In general, heavy metal analyses must be carried out by specialised laboratories. Specially treated bottles are required for sample collection.

There is no simple way for the community member to test for the presence of heavy metals. Contact any private water testing laboratory and arrange for them to do your testing for you. Be aware that there will be a cost involved.

Interpreting your results

Recommended upper limits for concentrations of a number of heavy metals are provided in the ANZECC (1992) guidelines for ecosystem protection, drinking water and agricultural use.

Examples of heavy metal guideline values

Heavy metal	Raw water for drinking purposes (subjected to coarse screening) mg/L	Protection of unfiltered aquatic ecosystems (unfiltered sample) mg/L	
		Fresh	Marine
Cadmium	0.005	0.0002 -0.002	0.002
Copper	1.0	0.002 - 0.005	0.005
Iron	0.3	0.500 - 1.000	
Lead	0.05	0.001 - 0.005	0.005
Manganese	0.1		
Mercury	0.001	0.0001	0.0001
Zinc	5.0	0.005 - 0.05	0.05

Flow

What is it?

Flow is the **volume** of water a stream or river discharges over a given amount of time.

Flow is measured in cubic metres per second (m^3/s) or megalitres per day (ML/d) (one megalitre is one million litres). By using the immediate flow rate for a water course the amount of material carried in the water can also be calculated.

Velocity is the distance that water travels over a given period of time; i.e. the **speed** of the water. Velocity is measured in metres per second (m/s).

How does it behave in the aquatic environment?

Natural flows of water courses will vary during the year and also from year to year. Animals and plants in and near watercourses depend on the natural flow patterns for growth, reproduction and the replenishment of nutrients in the land. For example, the river red gum needs regular yearly flooding to survive, fish migrations need increased flow for spawning, and flood plains get their nutrient-rich soils from floods.

Any changes in flow may impact on ecosystems by interrupting the flow requirements of the animals and plants. The natural flow may enable the stream to absorb inputs from the surrounding catchment and so reduce adverse side effects.

Often the natural flow is changed by humans as a result of dam constructions to service demands by irrigation, livestock watering, industrial and urban purposes. A reduction in the natural flow will reduce the ability of the stream to absorb inputs. Alternatively, stream flow may be increased, enabling the storage of water during high flow events and the releasing of this stored water during drier times when there is high water demand by the community.

Flow and water quality

The water quality in a stream can vary considerably depending on flow.

- **Moderate to moderately-high flows**

  The highest water quality in a stream normally occurs under moderately-high to moderate flows. Under these conditions there is sufficient flow to ensure good oxygenation of the water, to dilute and flush out pollutants, and to limit the build-up of algae.

- **Low flows**

  Under low flow conditions, sections of a stream may become semi-stagnant resulting in low oxygen levels and increased growth of algae. Salinity of the water may also increase and streams may be subject to larger variations in temperature which increases stress on the biota.

- **Flood flows**

  Under moderate and low flows, the water entering a stream is very largely derived from below-ground seepage. In contrast, during and immediately after heavy rainfall, water starts to flow over the surface of the ground. This water picks up all sorts of pollutants as it moves over the land surface and its quality is quite different to that of normal seepage inflow. As would be expected, such overland inflows cause marked changes to the normal quality of water in a stream. One obvious manifestation is the increase in suspended particles (i.e. the stream gets muddier) but there are changes to many other aspects of water quality. These changes in quality are generally greatest during the early stages of a flood, but may persist for days or even weeks after such an event.

  Because flow has a significant impact on water quality, it is important that we record it at the time of sampling (and if possible, during the previous few days). In particular we need to know if flows were 'normal', very low or very high.

How do you test for it?

Flow data may be available from your local Water Authority or state government agency if a gauging station is near your monitoring site.

If you have to collect your own data, a measurement of the average velocity of the flow along with a measurement of the area of a suitable section of the stream is required. The discharge is calculated by multiplying the area by the average velocity.

Suggestions about testing procedures

Measuring stream velocity - easy

1. Place a mark 10 metres upstream of your sampling site. Ideally, the stream bed should be straight, smooth and free of vegetation or other obstacles. Avoid using a culvert or bridge if the water is speeding up as it goes through. This accelerated velocity will not give a true estimate of the surface velocity of the stream. If the flow is very slow, or if the size of your stream varies a lot over 10 metres, then use a shorter distance.
2. Position a person at each end of this length.
3. Drop a gumnut or orange into the water 2 metres above your starting point to give it time to 'get into the flow'.
4. The first person calls 'Go' as the gumnut or orange reaches the starting point and the second one starts the stopwatch. They stop the stopwatch when the gumnut or orange reaches the end of the measured length.

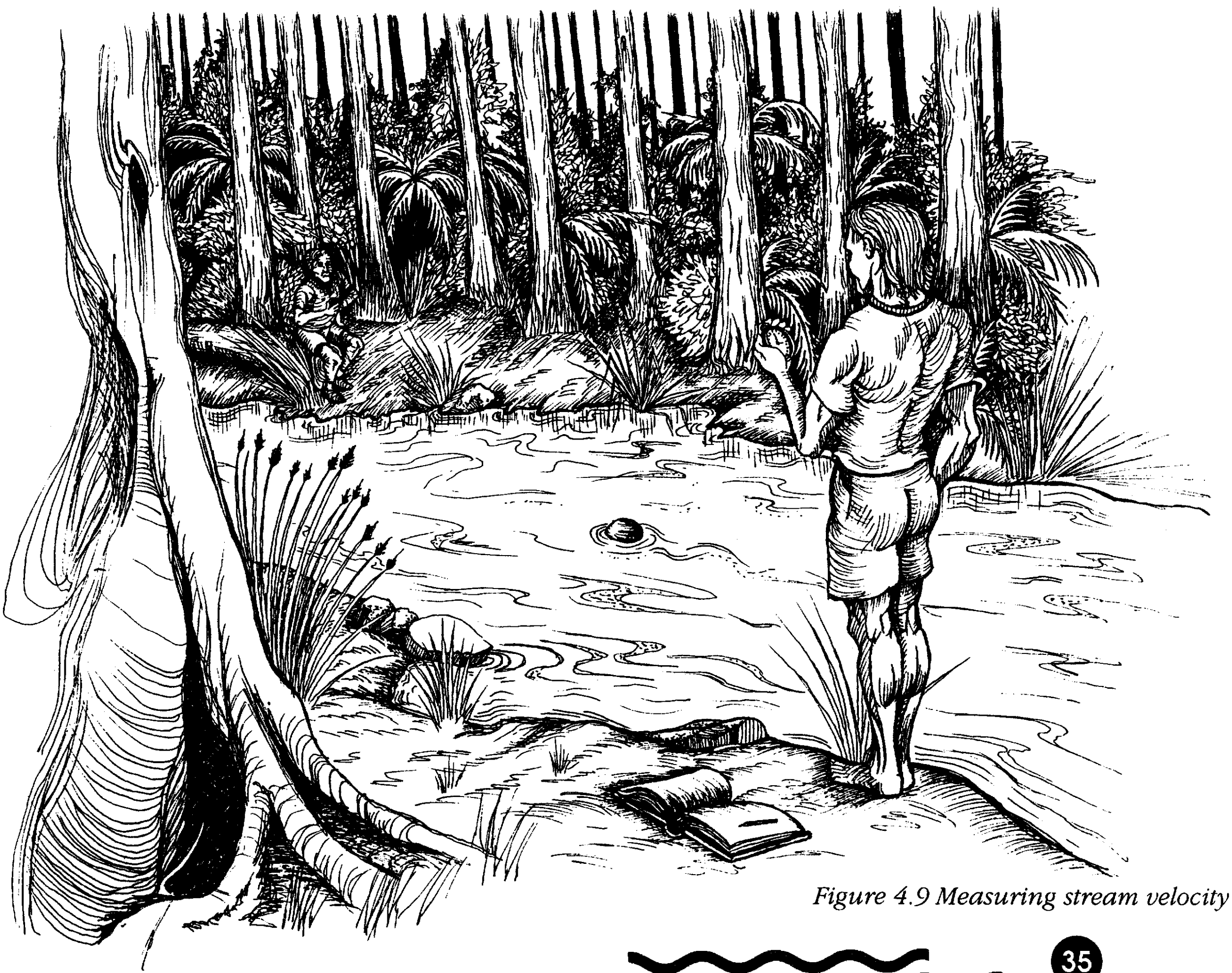

Figure 4.9 Measuring stream velocity

5. Repeat the exercise twice more in the same spot, and average the results to give velocity in m/s. An estimate of velocity is an essential measurement for calculating how much material the water is carrying.

6. Now repeat the entire exercise for a section of the stream near the middle. Average the side and middle results.

Note: To make the estimate of the stream velocity as close to reality as possible, you need to multiply the velocity obtained from the gumnut or orange moving in the fastest part of the stream by a correction factor. This allows for the total flow being uneven: it is slower at the edges than in the middle, and varies also from the surface to the depths. For gumnuts use a correction factor of 0.8; for oranges use a correction factor of 0.9.

Corrected velocity = $\dfrac{\textbf{distance travelled (metres) x correction factor}}{\textbf{average time taken (seconds)}}$

For example, if the average time taken for the gumnut to pass down a stream 4 metres long is 24 seconds, then

corrected velocity = $\dfrac{4.0 \text{ m} \times 0.8}{24 \text{ sec}}$ = 0.13 m/sec

Measuring stream flow - more difficult

The formula for measuring the flow of the stream is:

Stream flow (m^3/s) = cross-sectional area of water (sq metres) x corrected velocity (m/sec)

Note: 1 cubic metre = 1 000 litres so to get an idea of the rate of discharge in litres per second, multiply your answer by 1 000.

For small streambeds that dry up for part of the year you should take these measurements when the streambed is dry. For permanently flowing streams, you will need to find a bridge as close to your monitoring site as possible. Use the edge of the bridge deck as the horizontal datum line and mark the bridge supports with depth measurements to give you a permanent measuring stick.

Before you set up your string, find out the maximum height the water may reach later in the season. Look for signs of flooding or ask the neighbours. If it regularly overflows the banks, choose another site.

1. Use two posts or similar to stretch your measuring string (marked at 10 cm intervals) across the steambed. Make sure your location is above flood height and in a place where stock can't knock down the posts. Fibreglass electric fenceposts are good as their yellow colour makes them easy to spot (cost is about $2 each). Unfortunately it also makes them a target for light fingered people, so another suggestion is to use a couple of rocks and mark them with paint, so you can see them, but where they will not be spotted by people passing by.

2. **For a dry stream bed**
   Take measurements from the string (your 'datum line') to the bottom of the stream at 10 cm intervals. Record these as you work your way across the stream.
   For a stream with water in it
   If measuring from a bridge, lower a long dry pole from the bridge until it touches the stream bottom. Then measure the wet length of your pole to get the depth of the stream at that point. Repeat at 10 cm intervals as for a dry stream bed.

3. Record your measurements like this:

Points on datum line (metres)	Distance to streambed (metres)
0.10	0.10
0.20	0.18
0.30	0.20
0.40	0.32
0.50	0.56

4. From your recorded measurements draw the drain or stream cross-section on graph paper as shown in Figure 4.10.

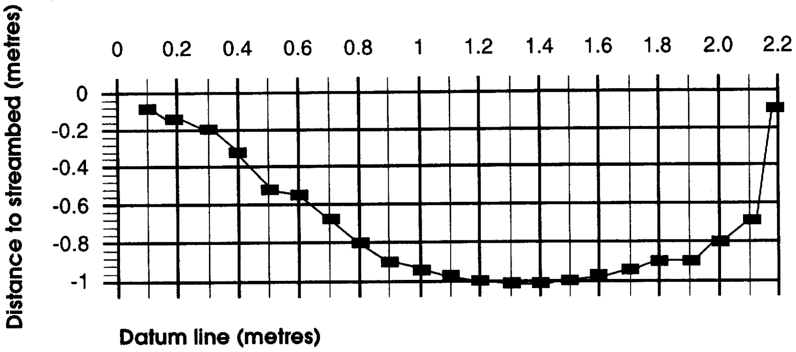

Figure 4.10 Sample stream cross-section

When you take a sample you also measure the distance from the datum line to a surface of the water. Mark this depth on the stream cross-section and draw a horizontal line across it at this point. To get the cross-sectional area of the streamflow simply add up the squares below this. For the streambed line, disregard squares which are less than half and count squares more than half as one. You should be able to make an accurate evaluation for the water height line.

Calculating your catchment loss rate

Accurate records of flow through time can not only be used to calculate average flows but also to measure other components of water quality. For example, by measuring the amount of phosphate in the water, we can estimate how much phosphate we are losing each hour. By then estimating the catchment area using a contour map we can estimate how much phosphate we are losing from each hectare during rain events.

The following table shows a fromula applied to an example. In the example, we calculated the loss rate for a sub-catchment of 63 ha, where there was a load of 0.12 mg/L for phosphate measured, and the streamflow was 260 m^3/s.

Formula	Example
1. Test for the water quality components and record your result ☐ mg/L	0.12 mg/L phosphate
2. Establish your stream flow in m^3/s Multiply by 3 600 000 to get litres per hour: ☐ L/hr	260 x 3 600 000 L/hr = 936 000 000 L/hr
3. Estimate the surface area of your catchment in hectares: ☐ ha	63 ha
4. To calculate the loss rate you multiply the result of Step 1. by the result of Step 2. and divide the answer by Step 3.	$\frac{0.12 \times 936\,000\,000}{63}$ =
Loss rate (mg/ha/hr) = $\frac{\text{instantaneous load (mg/L) x stream flow (L/hr)}}{\text{catchment area (ha)}}$	1 782 857.10 mg/hr/ha or 1.7825871 kg/hr/ha

Interpreting your results

Guidelines for flow

For protection of aquatic ecosystems	For drinking water	For recreation	For agriculture
Aquatic ecosystems can be affected by a change in flow regimes. Previously the extraction, storage and release of water for various uses has not generally considered aquatic ecosystem requirements. Requirements are specific for the natural ecosystems existing in a particular area.	No specific guideline	Recreational use can be affected by a change in flow regimes or by the provision of additional facilities such as artificial lakes. *Primary contact:* no specific guideline *Secondary contact:* no guideline *Visual use:* protection of aquatic ecosystems guidelines should apply	*Irrigation:* no specific guideline *Livestock:* no specific guideline

Interpreting all your physico-chemical results

It is important to obtain some baseline data for your catchment and compare any of your results against what has been found in the stream previously. Contact your Waterwatch co-ordinator if you need help locating baseline data.

Listed below is a set of rating guidelines from the 'State of the Environment' Report for a range of parameters. It provides a very broad but useful starting point for determining ratings for water quality. Using this table as a model, for your catchment, try and establish what is considered excellent through to degraded for the parameters you are measuring.

Rating guidelines for some tests

Parameter	Excellent	Good	Fair	Poor	Degraded
Conductivity (µS/cm EC)					
mountain	<30	<90	<150	<225	>225
valley	<80	<240	<400	<600	>600
plain	<100	<250	<500	<750	>750
Turbidity (NTU)					
mountain	<5.0	<7.5	<10.0	<12.5	>12.5
valley	<10.0	<12.5	<15.0	<22.5	> 22.5
plain	< 15.0	<17.5	<20.0	<30.0	>30.0
pH	6.0 -7.0	5.5 - 6 or <8.0	8.0 -8.5	5.0 -5.5 or 8.5 - 9.0	<5.0 or >9.0
Reactive Phosphorus (mg/L)	<0.008	<0.020	<0.040	<0.08	>0.08
Total Phosphorus (mg/L)	<0.010	<0.025	<0.050	<0.10	>0.10
Nitrates (mg/L)	<0.05	<0.1	<0.2	<0.4	>0.4
Total Nitrogen (mg/L)	< 0.2	0.2 - 0.35	0.35 - 0.50	0.50 - 1.00	>1.0
E. coli (o/m per 100 mL)	0 -50	51 - 200	201 -600	601 - 2000	>2000

Key:	< 'less than'	> 'more than'

(Source: State of the Environment Report - Victoria's Inland Waters)

Physical & Chemical Tests Record Sheet

Remember to complete a Site Description Sheet each time you conduct the chemical tests.

Name of monitoring group:	
Person(s) conducting the Survey / Test:	

Site grid reference

Date of Survey or Test: / /	**Easting** (4-digit no.)
Time of Survey or Tes:t a.m. / p.m.	**Northing** (5-digit no.)

Record the results for each of the tests you conducted in the table below.

Test	What it measures	Your result (units)	Comments
D.O.	Oxygen concentration	% sat.	
pH	Acidity/alkalinity		
Temperature	Temperature	°C	
Conductivity	Salinity	E.C.	
Turbidity	Suspended solids	N.T.U.	
Soluble Phosphate	Nutrient levels	mg/L	
Total Phosphate	Nutrient levels	mg/L	
Nitrates	Nutrient levels	mg/L	
E. coli	*E.coli* present	colonies per 100 mL	
Stream flow	Flow rate	litres/sec	