ENVIRONMENTAL PARAMETERS

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INTRODUCTION

Environmental parameters[2] influence the distribution, abundance and activity of animals and plants. Local meteorological conditions such as air temperature, rainfall or sunlight may affect the behaviour of terrestrial organisms, and water current, dissolved oxygen, suspended material and river bed topography may influence aquatic species.

Pesticides also behave differently under varying environmental conditions and information about soil type, soil moisture, the pH of water and the type of sediment are also instructive in pesticide impact assessment. The bioavailability of an insecticide is an expression of likely exposure of an organism to the toxin. A sandy soil will not bind (immobilize) some types of insecticide as well as clay soils, leaving organisms inhabiting sandy soils at greater risk. Soil moisture and pH can greatly modify the degradation rate of pesticides and, therefore, their persistence and bioavailability in the environment. The measurement of environmental parameters, therefore, becomes an integral part of any study design where the intention is to observe change in species, populations, activities or function as an outcome of pesticide use.

Field techniques for measuring a range of physical and physico-chemical parameters in air, water and soil are provided below. Environmental factors that primarily affect the abundance of plants, such as the concentration of the nutrients nitrogen, phosphorus and potassium in soils and water, are not described. The reason is that the wet chemistry involved is hard to manage in the field, at least for sustained periods. Plant nutrients also have little direct impact on fauna – the principal focus of this handbook.

The methods described are all fairly robust, reliable, cheap and practical to use. When it is not practical to visit sample sites daily because of the travelling distances involved, data loggers may be needed and, in long-term studies, a portable computer on to which data can be transferred. These items are expensive and under some circumstances it may be more cost-effective to employ field staff to reside at distant sample sites. The methods described have been tried and tested by all of the handbook's contributing authors, mostly for daily use and over periods of months to years. You will always lose some data: losses are minimized by forward planning (e.g. consumables or manpower scheduling) and by keeping fixed equipment out of sight of people and large mammals, protected from the latter by a wire fence if necessary. Biometricians can accommodate some gaps in the data sets but this is best avoided if at all possible!

STUDY DESIGN

Table 5.1 provides an indication of the environmental parameters that are important to integrate into study designs. Some are more or less essential (●) while others are optional (❍). Many of the parameters, like the meteorological conditions, are measured on a semi-continuous basis, perhaps every 30 min. Others are sampled

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[2] Factors or variables.

less regularly (e.g. conductivity and turbidity of water) or only once to establish a baseline (soil texture and water-holding capacity). It may be necessary to consider the influence of daily and season variations on biota, in which case both day and night-time readings of temperature and dissolved oxygen in shallow pools and lagoons will be required, accommodating wet and dry seasons as necessary. In practice, sampling intervals and periods will be constrained by the level of technology employed; a data logger can sample wind speed, relative humidity and temperature every 30 min; a maximum-minimum thermometer is read once a day.

The placement of meteorological equipment is mentioned in relevant sections below. Its importance relates to the compatibility of records with those of government meteorological survey and between stations established at sprayed and unsprayed sites, that can be hundreds of kilometres apart in some instances. Relatively simple precautions are necessary to ensure standardization of procedure and avoid the effect of buildings, tree stands and direct sunlight on parameters such as wind speed, wind direction, temperature and rainfall. When monitoring sites are further than 10–20 km apart, it may be necessary to set up more than one meteorological station, which has implications for resource management and frequency of reading. It may still be more cost-effective to have parameters read manually at fixed times of day rather than purchase expensive and vulnerable data logging equipment.

Table 5.1 Indicative measurements by study group/type

Study \ Parameter	Air/water temperature	% RH	Wind	Rain	DO/SS/UL	Current substrate	Soil texture	Soil WHC	Soil moisture	pH	Conductivity	Cover	Shade
Application technology	●	❍	●	●									
Pesticide residues	●	●	●	●			●			❍		❍	●
Soil processes	●	●	❍	●			●	●	●	●		●	
Terrestrial invertebrates	●	●	●	●								●	
Aquatic invertebrates	●		●	●	●	●				●	●	●	
Fish	●		❍	●	●	●				●	●	●	
Reptiles	●	●	●	●								●	●
Amphibia	●	●	●	●						●		●	●
Birds	●	●	●	●								●	❍
Small mammals	●	●	●	●			❍					●	❍

Key: RH = relative humidity; DO = dissolved oxygen; SS = suspended solids/turbidity; WHC = water-holding capacity; UL = underwater light (Secchi disk); ● required; ❍ optional.

METEOROLOGICAL MEASUREMENTS

Wind

Wind speed and direction provide useful information for predicting the heading of migratory pests, the direction of bird song, the distance and direction of travel of insecticide droplets, and the evaporation rates and residence times of pesticide residues on surfaces, etc. Wind speed and direction are best measured semi-continuously, and especially when pesticide application on a large scale is being monitored. This involves the use of costly anemometers, wind vanes and a data logger (totalling approximately US$ 2500, but this price represents only a fraction of the operational cost of the application). Direction can be inexpensively but crudely measured using a wind vane or windsock and a compass. Wind speed is readily measured using proprietary plastic gauges that use air pressure to raise a small plastic ball in a calibrated tube, or to rotate hemispherical cups fixed to a spindle of a calibrated anemometer.

Limitations Cost is a limitation in the first instance. All the methods require good placement of the measuring instruments, bearing in mind that obstacles to wind passage, huts, woods, paths and vegetation, will affect both wind speed and direction. It is preferable to stand or place instrumentation in a wide open space and to remember that mounting instrumentation on a mast to clear an obstacle will produce measurements representative of that height. Meteorological equipment left in the open for long periods is vulnerable to theft and interference by animals. Long-term installations should be protected by a tall wire fence, although that is no guarantee against elephant or baboon damage.

Processing Hand-held gauges are read directly. Data loggers will also read out directly or use software to compile averages and other statistics.

Resulting data Speed in $m\ s^{-1}$. Data can be represented in tabular or graphic form.

Sampling period Collect data over the entire monitoring period. Electronic data loggers can be set to record every 20 min. Manual intervals (wind gauge) should be used twice a day at the same time of day.

Equipment Anemometer or wind gauge, data logger, laptop computer, compass and wind vane.

Staff required 1.

Rainfall

Rain gauges of various designs provide data that are fundamental for the interpretation and comparison of biological and chemical information. Rain determines the growth of vegetation, soil microbial activity, the presence and behaviour of non-target organisms, pesticide dissipation, movement and degradation. Any container like a coffee can (flat bottom, straight sides) can be used to estimate rainfall. Rain gauges can be purchased or made from a funnel suspended over a graduated cylinder. For long-term, unattended use, a tipping bucket can compute rainfall using a mechanical counter or an electrical signal to a data logger. The height of water in the can or gauge is read off against a precipitation curve that takes account of the area of the opening and converts it to millimetres per unit of time.

Limitations Positioning of the gauge is important to reduce the effects of rain shadow (from buildings, trees, tall grass, etc.), splashing and evaporation, which is rapid in hot climates, especially at the beginning and end of a wet season. A tenth of a millimetre of rain will evaporate quickly if the gauge is not insulated or attended regularly.

Resulting data Millimetres of rain per day/month, etc., that is best represented as a histogram with time on the x axis.

Sampling period Collect data over the entire monitoring period. Check and empty gauges daily (as necessary).

Equipment Coffee can, funnel and volumetric cylinder (rain gauge), or tipping bucket.

Staff required 1.

Temperature

The temperature of air, water and soil is highly significant in terms of the distribution, behaviour and activity of biota and pesticides. Higher temperatures generally increase animal activity and this has implications for activity-based trapping techniques (e.g. pitfall traps) and the risk of contact with airborne droplets and surface deposits of pesticides. Temperature inversions at dusk and dawn affect the behaviour (dispersion) of pesticide droplets, while ambient temperatures affect significantly the toxicity of pesticides to most organisms – higher temperatures more commonly increasing toxicity, but lower temperatures increasing the toxicity of many pyrethroids. Pesticide degradation rates and persistence are markedly affected by temperature.

Mercury in glass thermometers provide an accurate way of measuring air, water and soil temperatures. Maximum-minimum thermometers are particularly useful for ecological impact assessment as they are cheap, robust tools that are easily reset for daily recording. Hand-held, electronic temperature sensors are also good but expensive and require long-life batteries. Most portable meters available for determination of pH, oxygen and conductivity have integral temperature sensors that can read out separately from the main function. Meteorological data loggers will have an input for a thermistor or thermocouple.
Limitations Protect thermistors and the bulb of mercury thermometers from direct sunlight when measuring air temperature (best to provide a wooden or polystyrene screen).
Processing None except basic statistics (averaging, range, maximum-minimum).
Resulting data °C. Line graphs (*x* axis for time) or tables as appropriate.
Sampling period Collect data over the entire monitoring period – setting data loggers to record every 20 min. Manual readings should be taken at dawn, midday and dusk.
Equipment Thermometers, maximum–minimum thermometers or electronic devices employing thermistors.
Staff required 1.

Relative humidity

The speed with which many biota dehydrate is related to the humidity or moisture content of the surrounding air. They lose water very quickly by evaporation through the skin and cuticle when the humidity is low, and the process is aggravated by high ambient temperature and wind speeds. Many species are inactive in dry conditions and small amounts of shade or cover can significantly affect the degree of animal activity, especially above ground. Local conditions influence soil moisture and microbial activity, such that the rate of biological degradation of pesticide is accelerated in more moist areas. Pesticides which 'knock-down' invertebrates (e.g. pyrethroids) often also cause spiracles to open, subjecting them to a risk of desiccation at low relative humidity.

The best instrument with which to measure humidity is the whirling hygrometer as it is fast, accurate and cheaper than electronic humidity probes. The measurement is based on the differential between two thermometers, one of which has a mercury bulb that is kept wet by a wick in a water reservoir, the other not. When the hygrometer is spun around in air (like a football rattle), the water in the wick evaporates as a function of humidity and cools the bulb. The lower the humidity the greater the cooling and the difference in bulb temperature of the two thermometers is used to calculate the relative humidity.
Limitations Microhabitat differences can affect percentage relative humidity.
Processing Differences in temperature are converted to relative humidity using the tables provided with the instrument.
Resulting data Percentage relative humidity plotted against time or as a radial plot for a spatial representation.
Sampling period Take a reading at the same time of day throughout the monitoring period. Set a data logger to record relative humidity every hour.
Equipment Whirling hygrometer.
Staff required 1.

OTHER PHYSICAL AND PHYSICO-CHEMICAL MEASUREMENTS

Water temperature

See general points under 'Temperature' above.

Water temperature can vary widely over 24 h. In the dry season, shallow water bodies, swamp and lagoons can cool by 10 °C between dusk and dawn and shallow, slow moving rivers may do likewise. The physiological activity of fish and invertebrates is very different at the extremes of the range, and biological sampling procedures should take account of it. At the high end, fish and invertebrates are under more natural stress in shallow water due to increased respiration, lowered dissolved oxygen levels and increased toxicity of many pesticides. In deeper rivers, pools and lakes, the temperature extremes are narrower and the dilution factor ameliorates the acute toxicity of deposited pesticide (not for surface-dwelling invertebrates).

Mercury in glass or electronic thermometers are easily used from the shore, while wading or from boats. A weighted thermistor or thermocouple attached to a cable is useful for measuring at depths. Dissolved oxygen electrodes have integral thermometers and generally longer cables.

Limitations Depth of measurement. The length of cable may constrain deep measurements.

Resulting data Average daily temperature, which may be plotted as a line graph over time.

Sampling period Every time a fish or invertebrate sample is taken in a water body. Data loggers can be set to record temperature every 20 min.

Equipment Glass or electronic thermometer, or thermistor/thermocouple attached to oxygen or conductivity electrodes.

Staff required 1.

Dissolved oxygen

The amount of dissolved oxygen in water is in a constant state of flux. This is a natural result of the influences of water temperature, plant photosynthesis and respiration and organic matter breakdown. Organic pollution and nutrient enrichment increase the exposure of aquatic organisms to a much larger range of oxygen concentrations, and the potential impact can be limiting to a huge range of species as most require, and are sensitive to, dissolved oxygen. Under these conditions it is not unusual to see daily fluctuations ranging from the severely limiting (5–10% saturation) to supersaturation (150% saturation), which can also be limiting. Dissolved oxygen in water is one of the key parameters that aquatic ecotoxicologists need to measure. The physiological stress induced from exposure to pesticides combined with that from low dissolved oxygen levels can be fatal for aquatic organisms.

Measurement of dissolved oxygen in water is relatively straightforward with a portable oxygen meter. A calibrated oxygen electrode is moved slowly in water to produce a reading in ppm of oxygen after 1–2 min. Meters and electrodes are fairly expensive and require good maintenance and long-life batteries, but the alternative (the more accurate Winkler method) is time-consuming wet chemistry, and unsuitable for sustained periods in the field.

Limitations Electrodes are delicate and require calibration every 1–2 days, although for most field purposes, water-saturated air is sufficient to check the calibration. Most meters have automatic temperature compensation but it may be necessary to correct for temperature and pressure with older models. Semi-continuous logging of data is not that practical over long periods: water must move over the electrode tip and continuous immersion in water encourages algal and bacterial growth on the membrane. Devise a schedule of visits to sample sites to ensure that measurements are made at approximately the same time of day at each visit (to accommodate photosynthetic activity). This becomes difficult when large distances need to be covered on land or lake.

Processing None, although older meters may not automatically compensate for temperature and pressure in calculation of percentage saturation with oxygen.

Resulting data ppm oxygen and percentage oxygen saturation.

Sampling period Take readings when sampling aquatic habitats. It is also useful to know hourly dissolved oxygen over a 24 h period. Set data loggers to record every 20 min.

Equipment Portable oxygen meter, temperature compensating electrode and cable.

Staff required 1.

pH

The acidity and alkalinity of soil and water can be estimated from a pH scale. In the case of soil, an aqueous slurry or extraction is prepared before measurement. Soil pH may change slightly with season, leaf-fall, leaching and cropping practices. The pH of water may fluctuate considerably as photosynthetic activity removes carbon dioxide from water and shifts the carbonate-bicarbonate equilibrium. The real significance of pH in soils is its effect on plant nutrient availability but for ecotoxicology, the pH of water and soil can influence the toxicity of pesticides and their rate of degradation.

Colorimetric and electrometric methods are used to measure pH. The latter is more sensitive and involves immersing two electrodes (a pH and a reference), or a combined electrode, in a soil solution or water and reading the pH from a meter within 1–2 min. The less accurate but much cheaper colorimetric method involves the use of colour indicators or, more conveniently, pH papers, that are dipped into the solution and read from a colour chart.
Limitations pH electrodes are delicate and easily broken in the field. Always carry spares of both electrodes and batteries. They also need regular (daily) calibration, which requires carrying 2–3 buffer solutions and distilled water. pH papers are subject to operator influences, colour perception, etc.
Processing Equal volumes of distilled water and soil are stirred for a few minutes before immersing the electrodes or dipping the indicator paper.
Resulting data pH units – to 0.01 with an electrode and within 0.5 of a unit with narrow range paper.
Sampling period Take readings when sampling aquatic habitats.
Equipment pH and reference electrodes, pH meter and buffers, and/or pH indicator paper.
Staff required 1.

Light and shade

In the context of this handbook, light and shade measurements are primarily used to classify terrestrial habitats or describe diurnal and seasonal change. It is the influence of light and shade on animal activity and behaviour that concerns us more than aspects of plant growth and photosynthesis, because population measurements of fauna can become distorted as behaviour changes in response to light. Gradations of light intensity, from full sunlight to deep shade, can also affect persistence of pesticides on surfaces like vegetation and soil, as UV radiation begins to degrade organic compounds.

There is a range of light meters available with sensors designed for the measurement of various types of radiation (e.g. photon irradiance, energy flux, and lux). For simple comparison and recording of light levels in different habitats, a meter with arbitrary units is sufficient, but access to a PAR (photosynthetically active radiation) or lux meter will also suffice for the purpose. Many ecologists take note of the light conditions along transects as they walk, using gradations from full sunlight to full shade to record the conditions when they observed species of insects, reptiles or birds. Combining light measurement with a percentage of vegetation cover (where relevant) is also useful. The cover afforded to ground fauna by a woodland canopy or a riverine sampling site can be estimated crudely by holding up a small quadrat and noting the percentage of clear sky, cloud, canopy, etc. No method sheet is provided for light readings.
Limitations None provided the output is to be used for comparative purposes.
Processing None.
Resulting data Light units or estimated gradations of light/cover can be plotted or tabulated.
Equipment Light meter and sensor, and small quadrat.
Staff required 1.

Turbidity/underwater light

Light penetration into water is sometimes measured in relation to production and behaviour of phytoplankton and fish and to estimate reduction of light caused by floating weed infestations. A Secchi disc is a simple

apparatus used widely for this purpose. The black and white disc is lowered into the water until it just disappears from view and the depth is noted from the line supporting it. It is then lowered further and raised until it becomes visible, to provide a further reading. Comparative measurements over time are easily made and readings can be converted to euphotic zone depth if required (factors can be found in limnology textbooks). (Look under turbidity in method sheet on physico-chemical measurements in water.)
Limitations User variability, changes in ambient light conditions and surface disturbances (ripples, waves) reduce precision and accuracy.
Resulting data In centimetres or metres. Data can easily be graphed as histograms.
Sampling period Take a reading when sampling ponds, lakes and lagoons.
Equipment Secchi disc, and weight and line.
Staff required 1.

Turbidity/suspended solids

Suspended inorganic and organic matter can affect the availability of pesticides in water. Many pesticides bind quite strongly to suspended particulate matter and will be removed downstream of a contaminated area fairly quickly. Turbid rivers give high degrees of protection to local fauna and dilution downstream may mitigate some of the toxic effects, even for filter feeding species. Suspended solids also reduce light penetration into water, affecting phytoplankton, the visibility of aquatic fauna and sometimes the viability of fish eggs. Turbidity meters and solids monitors are expensive. The simplest, reliable field method is a gravimetric determination, requiring a representative sample of water that is passed through a weighed filter paper, which is then oven or sun-dried and reweighed. A Secchi disc can also be used to estimate turbidity providing the depth of water is sufficient to allow its disappearance from view.
Limitations Very turbid water will take a long time to filter without a vacuum pump.
Processing None.
Resulting data Data can be readily plotted or tabulated (in ppm).
Sampling period Sample water to determine suspended solids one or twice a month.
Equipment Plastic graduated cylinder, Hartley or Buchner funnel and flask, filter papers and portable balance (if laboratory too far away).
Staff required 1.

Conductivity

Conductivity of water is a parameter that does not vary greatly under natural conditions, with the exception of estuarine conditions and where saline intrusion into lakes occurs. The ionic concentration of materials dissolved in water is measured with a probe and the conductivity is read from a hand-held meter. Conductivity has little relevance to pesticide impact assessment except where saline intrusion into water bodies occurs intermittently, as it may affect the physiology and distribution of fauna.
Limitations None – the probes are robust and stable.
Processing None.
Resulting data Outputs in ohm^{-1} or Siemens cm^{-1}.
Sampling period Take a reading when sampling aquatic habitats, particularly if they are subject to saline intrusion.
Equipment Conductivity meter and probe.
Staff required 1.

Current velocity

Current changes with season, slope and interventions such as dam releases. Water velocity has a profound effect on physico-chemistry, the composition of a river bed (sand, silt) and the ability of invertebrates to keep a foothold, respire and feed. Aquatic invertebrates are particularly sensitive to pesticides and may drift downstream to avoid them. It is important to be able to distinguish between population change due to pollution from other causes such as a change in current. Variable flow can have a far greater impact on benthic populations than low level pesticide contamination. Flow measurement is also useful to match monitoring sites within and between reaches of a river. Three methods that are very straightforward are commonly used.

- Timing of a float, often a fruit like an orange, over a known distance. Its advantage is that it is quick, can be repeated to achieve an average and requires no equipment except a watch and a floating object. Most of the float should be submerged and the float should be timed over a reasonable distance, e.g. 10–20 m.
- Use of a Gessner tube, using the time taken for water to inflate a bag.
- A propeller-based flow meter is much more accurate and is often used when differences in speed at various depths (vertical profile) are required. Propellor systems can be used to measure flow through aquatic drift nets although they must be custom made to fit the net.

Limitations The float technique is imprecise because of obstructions in the river, the effect of strong wind, and problems arising from main and peripheral flow in streams – the float takes its own path. Gessner tubes may not be commercially available in some countries but can be fabricated easily enough. Propeller-based systems are expensive (US$1500).
Processing None.
Resulting data Output in m s^{-1}.
Sampling period Sample flow whenever setting a drift trap and check flows at sample sites every 2 weeks, or more frequently after rain or when streams are drying out.
Equipment Stop-watch, tape measure, and float or Gessner tube.
Staff required 1.

Classification of aquatic substrates

Aquatic invertebrates are associated with certain types of substratum. Some species prefer mud, others gravel or rocks. Substratum is thus another factor that controls the distribution and range of benthic invertebrates and for the purposes of surveillance and monitoring, we need to try and match sampling sites as closely as possible. Methods for classifying substrates can be rapid or lengthy depending on the goal. For the siting of sampling stations, a rapid analysis based on visual estimates will normally suffice, using a percentage scale to characterize the area covered by rocks, pebbles, gravel and sand, silt and mud, emergent or rooted vegetation. Over long reaches of river matching of sample sites is often difficult, as rivers begin to deposit sediment when the slope declines and in the slack of bends. Current velocity is closely related to the substratum and these two parameters are fundamental for site characterization. The more exacting method of classification that uses particle size analysis and settling characteristics of silt and clay is not a practical option in the field but a method to separate broader substrate types is included in the method sheet. A series of sieves and a tape measure is all that is required to classify substrate (Table 5.2).

Estimating vegetative cover

The importance of the positioning of terrestrial sample sites used for comparative studies of fauna is an argument that is vigorously exercised throughout this handbook. Visual estimates of the vegetative/ground cover are an aid for the siting of sampling stations, traps and survey lines. Ecologists carry pictures of habitat type in their minds (also now, digital camera images) when surveying for sites that can be up to hundreds of kilometres apart. They will be looking for similarities in plant biomass, plant cover, height, and species distribution which can be characterized rapidly by visual surveys of cover – in anything from small plots to large study areas. The ultimate test of well-matched sites will of course be the variation in faunal population data, but the efficiency of testing is improved by applying baseline knowledge of plant cover.

The simplest method of site survey is to rank species of vegetation as abundant, frequent, occasional or rare. Dominant vegetation is often used as a fifth descriptor of the habitat, e.g. *miombo* woodland or *Cynodon* grassland. As these rankings are open to interpretation it is useful to define percentages to them for all observers to work to. For

Table 5.2 Substrate categories and their particle size

Name	Size range	US standard mesh number
Clay	<3.9 µm	
Silt	3.9–63 µm	
Fine sand	0.02–0.25 mm	120
Medium sand	0.25–0.5 mm	60
Coarse sand	0.5–1.0 mm	35
Gravel	2–16 mm	10–5
Pebble	16–64 mm	
Rocks	64–256 mm	
Boulder	>256 mm	

example, the Braun-Blanquet scale assigns percentage cover to the rankings. More detail and quantification can be provided by the use of quadrats but at this level of information retrieval, time might be better invested in surveying the animal populations for indications of similarity and abundance. The reader is referred to the book by Grieg-Smith (1983) for quadrat sampling and other vegetation survey methods.

Limitations The subjective interpretation of cover can often lead to inaccuracies and inequalities in the data. The error between operators is hard to quantify and so variation is best reduced if the same individual or team is responsible for all the survey work. Ranked data can be used in non-parametric (statistical) tests but their discriminative power is poor. These drawbacks are compensated for by survey speed.

Processing Ranking of data.

Resulting data Area maps with histograms or area plots showing cover.

Sampling period Normally once, at the time of siting areas for monitoring, but it may need to be repeated if survey periods extend over different seasons.

Staff required: 2.

Soil texture

Choosing comparable sites for the measurement of soil microbial processes, soil invertebrate activity, pesticide residues in soil, etc., requires the assessment of soil texture. Laboratory methods are not feasible in remote areas but a ready guide to soil texture can be obtained from the feel of a soil. It takes some practice but is surprisingly accurate and only requires a trowel and water.

Limitation The only limitation is inexperience which can be overcome by using the technique against soils of known mineral composition (standard soils). No equipment or data processing is necessary. If you can find a soil testing laboratory to assess particle size, the method sheet provides a soil classification based on percentage sand, silt and clay.

Sampling period Normally once, at the time of site selection.

Staff required 1.

Soil moisture

Why is it necessary to measure soil moisture. The methods described for field estimation of soil moisture and water-holding capacity are crude compared with laboratory techniques but sensitive enough to provide standardization of field experiments designed to estimate nitrification or respiration. Moisture is determined by

weighing freshly dug soil before and after drying and expressing the difference as a percentage of dry soil weight (a quirk of soil science).
Limitations Soil moisture varies with soil type (texture, mineral and organic matter content), vegetative cover (shade and evapo-transpiration) and climatic conditions such as the time of day, cloud cover, rainfall and wind speed.
Processing None.
Resulting data A percentage of water in soil (dry weight).
Sampling period Up to 12 h if sun-drying the soil.
Equipment Portable balance and 2 mm sieve if determining in the field, polythene bags and Petri dishes.
Staff required 1.

Soil water-holding capacity

Water-holding capacity is used to describe water available for plant growth. The term is not synonymous with field capacity, which describes the water-holding capacity after water has ceased to move downwards in the soil under gravity. For the purposes of estimating soil nitrification, where prepared (sieved) soils are used, the first water-holding capacity method (1) is satisfactory. The methods (2) are simple to perform and rely on basic equipment.
Limitations Because it is rarely possible to completely dry soils in the field, it is advisable to check their moisture content by oven-drying a few samples on return to the laboratory. Quantitative measures of field capacity require laboratory-based techniques.
Resulting data Weight or percentage of retained water.
Sampling period 1 day is sufficient.
Equipment Balance or portable balance (in the field) and filter papers.
Staff required 1.

RECORDING DEVICES

Data loggers have revolutionized the monitoring of environmental parameters. They have become more manageable (hand-held), reliable and versatile: storage capacity and connectivity has improved and real-time telemetric links and downloads are possible. They remain expensive, however, and are vulnerable to theft, as they are often left in remote places for long periods of time. Even small, hand-held meters have storage capacity for hundreds of readings and many are multi-functional, allowing programming of inputs from temperature, oxygen, conductivity, pH and humidity probes. Data loggers are ideal for long-term meteorological monitoring, although the risk of losing large data sets increases unless data can be downloaded regularly through visits or by telephone. The major constraint to remote use is battery power.
Limitations Major cost and risks of damage and theft to unattended devices.
Processing Processing is easy; ample programmable and statistical functionality.

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FURTHER READING

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