AUSTRALASIAN MINE SAFETY

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Inside....

pH 1.5 – 3, and that a 'balanced' skin has a surface pH of about 5.4 -5.9. Pharmaceutical evaluations and testing for drug effects often take into consideration the protective "Acid Skin Mantle"[1]. Below the skin's outer layers the pH suddenly rises and values like 7.2 – 7.5 are more common[2]. Studies on skin pH have been undertaken since at least the 1920s and still proceed. The alkaline response condition has been receiving considerable attention because it seems that alkaline substances seem to burn or irritate skin more slowly, or at least less noticeably, than acids. As a result the effects can be very serious because they are unnoticed[3, 4].

In undisturbed natural ecosystems extremes of pH in groundwater are not common, and pH typically varies between 4.0 or 5 in areas with actively oxidised sulfides to 9.0 in carbonate-buffered systems. The Earth's systems function in an ever-changing regimen of coupled acid-base pairs[5] which fosters an even-handed outcome. However, groundwater can exhibit a very large range of values; some reported include pH 1.9 in sulphurous springs of volcanic origin and pH 11.8 in ultrabasic rock.[6]

Geologists, environmental and operational management personnel will probably be the ones most likely to be confronted with an evaluation of water physio-chemistry. This can occur in routine, exploratory or irregular sampling and testing programs, and typically involves the measurement of groundwater levels in piezometers, wells or open boreholes or sampling in the same situations. The assessment and sampling of springs, seeps, ponds and streams are other instances not to be forgotten. Borehole dippers, pumps, bailers, capture bottles, probes and sondes, together with their measuring or control lines/cables, are all subject to experiencing high end pH waters and retaining this on their surfaces and within sonde and probe housings, as well as in and on winding and storage mechanisms and gear.

Broadly, two sets of circumstances could be anticipated to warrant consideration prior to relevant fieldwork. Firstly, if working in a new area, consideration of likely drilling conditions (rock and ore types, likely groundwater occurrence) should be made. If the investigation is targeting a likely resource associated with acidic or alkaline waters, then appropriate safety measures that prevent water contact with skin should be taken from the outset. As measurements become available they need to be considered for what they are indicating in terms of chemical risk. Thus pH probe measurements (with frequently re-calibrated devices) should be taken early on. The emphasis here is on pH, but equally other chemical indicators may need to be assessed by using a cautious approach in the first instance.

Secondly, the issue arises where new or inexperienced personnel take on initial or routine assessment of waters. Specific situations could be as diverse as accompanying an existing drilling team, or regular measurement of draw-down levels in monitoring bores coupled with dewatering operations. There is a responsibility for supervising officers to brief the new personnel on likely conditions and any necessary precautions that should be considered – at least in the first instance. Really, no-one should be undertaking the tasks discussed here without some assessment of risk to themselves and colleagues, and some review of necessary procedures. As more information becomes available and more knowledge develops from regular measurement, sampling or inspection, then different considerations might apply.

In addition, in-field consideration and prior preparation is also important where routine measuring or collecting is occurring. This situation envisages the previous collection of a number of measurements of pH or other testing for other analytes. Furthermore, it is likely that the operational, exploration or planning issues related have not significantly changed. The data should be considered ahead of the task; the personnel are looking at absolute values, relative values, trends and amount of change: i.e. irregularities or key pointers (e.g. a pH value) that might herald caution. How is this done?

It is not sufficient to simply feed measurements of water analytes (or levels) into a database without a consideration of their significance – either at the time of data recording or in a suitable near-term timeframe. Water analyte data is usually best considered by graphical analysis; for water levels this is usually a continuous line graph – but ideally these would be nested (or multi-nested) for a project so that variations in any one are considered against others. In the case of an analyte reading like pH, this could also be a line graph, but bar/column plots often give a more readable picture. It's important that graph scales properly reflect the accuracy of the measurement and the spread of likely results. For instance, a pH change of 1 unit may be important to record, but not a change of 0.1 unit; maybe a graph scale with 0.5 unit intervals is sufficient. Also note, that in field operations, even though the meter may record a measurement to 2 or 3 decimal places, the accuracy of the whole sampling process rarely reflects the scope of the instrumentation (but that's to do with sampling theory)! Schoeller or Stiff diagrams often provide useful presentation for water sampling data and allow routine and ready monitoring of change.

Any measurement group accompanied by some chart showing the degree of

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measurement change between successive results can be really useful in indicating trends or issues with reliability or technique. Finally, it should be borne in mind that the measurement or sampling exercise has a cost; the data or result therefore deserves to be given more than scant attention – it may impact on operational and licensing issues, but may also impact on personnel and safety.

There could be a myriad of reasons why one might see change in a routine set of pH measurements. So apart from considering safety aspects and dealing with these appropriately, it would be timely to reflect upon matters like: has a dam been breached, or an underground cavity or fault/shear zone been intersected; has the groundwater flow regime changed, or an area become dried out or oxidised due to a falling watertable; has a new area of mineralisation been intersected or has leachate from a dump reached the groundwater. The phenomenon of detected change is the trigger to re-evaluate water handling procedures in this regime.

But burning groundwater is not only due to pH effects. There are at least 2 or 3 other instances that should command consideration of likely safe handling matters or require precautions for personnel protection. These are temperature, radioactivity and drying effects.

The primary concern with water temperature is heat, since when it is cold, water approaches the frozen state and is difficult to sample as a liquid. However, in situations, not common in Australia, where running water is associated with ice, ground- or melt- waters can be cold and can affect exposed skin. A bonus in cold environments and coldwater situations is that weathering rates decrease, and waters are less likely to have major solute concentrations and/or have very low or high pH.

In Australia and nearby Oceania and Asia, there is a current significant interest in geothermal water sources, as well as in tapping hot dry rock energy. Both situations can lead to personnel dealing routinely with water approaching boiling point, or super-heated water (> 100 °C) under pressure. In both situations the likelihood of encountering very hot water (and/or pressurised and/or sulphurous waters - maybe acid) should be carefully evaluated before tapping, measuring or sampling. In Australia, thermal and mineralised springs are known and relate to significant tourist and commercial/energy operations in some towns. High temperature artesian waters from the Great Artesian Basin are common.

In non-volcanic areas, near-surface groundwater generally reflects the average temperature of the ground; whereas slightly deeper water if it has had sufficient time to equilibrate with rock strata has this heat plus an increase for the geothermal gradient. The geothermal gradient is highly variable, depending not only on the tectonic setting but also the characteristics of the host rock. In coalified strata, or igneous intrusive rocks for example, water temperatures are slightly higher than in surface sedimentary layers. But generally, these waters are of low to modest natural temperature and easily handled.

Radioactive waters are more likely to be a problem because of the suspended or dissolved radionuclides that they host rather than temperature, although both issues can be concurrent in some thermal springs. As the degree of radioactivity increases the propensity of these waters to burn, or cause longer term skin damage that might not be immediately apparent, also increases. In addition, there are the other potential effects of exposure to radioactivity. Personnel dealing with such waters need to be well trained in assessing the likelihood of exposure from the earliest times and should make routine measurements of the radioactivity and take necessary precautions if sampling or measuring water levels. In these situations attention to the decontamination and general good handling of field equipment is essential. It is vital that all new or replacement staff be acquainted with measured trends and spot data from the waters and be taught to evaluate their risks before commencing work.

A special situation can arise when sampling and handling groundwater where attention has been given to sterile conditions in order to enable microbiological evaluation. In such cases all equipment has to be routinely sterilised between measurements or samples. This can be done by a number of techniques but one satisfactorily used repeatedly by the author in the field has been running methylated spirit mixture through pump and sampling equipment[7]. Handling this gear and the solution repeatedly can lead to a drying of the hands' skin despite significant efforts to wear gloves and handle with caution. The use of thin gloves e.g. nitrile-based in the field sounds easy, but is often accompanied by an increase in the difficulty of the tasks when handling delicate, wet and/or slimy equipment.

So returning to the original question – "yes", the groundwater could have burnt you. It's not always an innocuous, simple solution just waiting to be measured or sampled. It can be high or low in pH, hot, cold or radioactive; and furthermore in special situations the carrier of noxious chemicals, bacteria, viruses, or other microscopic life forms. Groundwater sampling and handling at mine and development sites is typically routine and of low risk and few complications; but there are many notable exceptions. Add-in an exploratory or preliminary evaluation context and you may have a nasty situation that should be approached by deliberate and a priori evaluation of the risks.

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