Looking for Uranium in environmental samples with a microscope

In the last five years the issue of post-battlefield uranium contamination of the environment has become an increasingly important issue. Uranium weapons produce large quantities of uranium oxide dust which travel great distances, but to locate the dust and prove the use of uranium weapons is difficult. It is even difficult for the authorities who have access to expensive and complex equipment. In Kosovo, the first UNEP expedition, and all of the military expeditions from the different KFOR armies stated that there was no uranium contamination, because their Geiger counters had not given any indication of increased radiation levels. A later expedition by UNEP in 2001 which took samples and had them analysed, found that there was widespread contamination by Depleted Uranium. How are members of the public to look for uranium?

Scintillation counters and Geiger Counters

I have looked for, and found DU in Kosovo, and also in Iraq. I was in Kosovo with Nippon Television before UNEP reported. We were freezing in the mountains, and I was trailing a scintillation counter along the ground in zigzag transects to detect increased beta- radiation. For the problem is this: Uranium is an alpha emitter: it does not produce much in the way of gamma. And Geiger counters only react to gamma because they have vacuum tubes with windows that alpha- (and even a large proportion of beta-) radiations will not penetrate. So you should be very cautious about accepting what anyone tells you about the absence of uranium in an area on the basis of Geiger Counter readings. The method is no use. So what can we do? What should be done?

U-238, the main component of DU (and also enriched uranium) has two decay products. Thorium-234 and Protoactinium-234m which are both beta emitters. It is the beta radiations that can be detected with a thin window scintillation counter like the ones developed by the UK nuclear industry for decontamination. I use one of these, a DP2 4 inch square probe which I use with an Electra 1A battery operated counter. This was bought for us by the Irish government when I was carrying out my Irish Sea radiation work in 1998. The outfit is expensive, costing about £2000 these days, and indeed, anything that will detect beta with sufficient sensitivity to be useful will cost about the same. So it is not the kind of thing that the ordinary citizen will be able to afford; and it is sensitive to damage. The window is so thin that a blade of grass will put a hole in it, and a new window is expensive.

A survey with such an instrument will show when there is something there. The places that uranium dust collects are where the rain washes fine dust and then evaporates. So you must look in dried up puddles and in gutters, anywhere where the finest dust washes down to. And then trail the scintillation counter along the ground about 10cm from the surface, being careful not to poke a hole in the window or snag it on a twig. If you find dust that is two or three times as active as background, then there is something there. But you have to be careful, as proximity to buildings will give higher readings, and sometimes hollows also i.e. at the bottom of a trench or crater, because gamma rays from soil be then be coming from the sides as well as the bottom of the detector. This is the method that finds the uranium in the first place; but it only tells you that there is something there that gives a higher than normal beta-ray reading. To be certain it is uranium the dust sample has to go off for analysis. Once you have found an area of higher than normal background activity (two or three times) then you take the sample, transfer it to a plastic bag, and send it for laboratory analysis by mass spectrometry or alpha spectrometry. Locating the initial samples is important. We have had many blind samples sent to us and analysis paid for when there is nothing there. This can be costly as a lab analysis is about £250-£400

The barefoot environmental surveyor.
So let me present a cheap alternative. It uses a special plastic called allyl diglycol carbonate, trade name CR39. This plastic has the property of being able to register alpha particle tracks, and is routinely employed by government risk agencies to measure radon activity in homes (Radon is an alpha emitter). The clear plastic, as sheet material of thickness 1mm or so, is available from a number of sources, one being TASL in Bristol. We purchase it from an Italian source. Smaller pieces can be used or sheet material can be cut into any size you wish. I first began using it following a suggestion by Eric Hamilton the Chief Chemist (now retired) of the National Radiological Protection Board., who pioneered its use for examining hot particles in the Irish Sea. I would obtain a mud core by driving a piece of plastic pipe into the mud on an estuary where there was suspected Sellafield contamination. I would then dig round the pipe, lift it out, take it back home and put it in a freezer. Whilst frozen, I would then cut the pipe and core along its length with a saw and dry out the two halves. A 10 inch strip of CR39 plastic, 1cm wide , would be placed along the mud core and left for 24 hours in the freezer. The plastic would register any alpha activity from hot particles (e.g. plutonium) and these would be revealed on etching the plastic in caustic soda as I shall describe below.

For uranium detection in dust samples you can proceed as follows. A piece of plastic about 1cm x 3cm is placed in contact with the sample such that it is half on and half off the unknown sample. The area that is not in contact acts as a control (since there is always some radon which will create a few tracks). The sample and plastic should be then left undisturbed in the top of a freezer, to limit the radon activity (the gas is heavy and will be mostly in the bottom of the freezer). But it's not absolutely necessary to have a freezer, because you have a control piece of plastic to compare tracks with. After a measured length of time, usually about 15 to 24 hours depending on the activity you find, the plastic sample is removed, washed with water, and transferred to a beaker of concentrated caustic soda (sodium hydroxide) or preferably potassium hydroxide. The concentration should be about 6 Normal as a chemist would say). For Potassium hydroxide this contains 17gm of KOH (potassium hydroxide) added to 50ml of water. For sodium hydroxide, NaOH, it is 12gm per 50 ml. (The concentration is not critical; when you are adding the dry caustic soda flakes to the solution you can have 2 grams more than I have recommended, or 2 grams less — it will still work).

TASL provide instructions for use of their TASTRAK plastic. **BUT BE CAREFUL**. Concentrated caustic soda and caustic potash solutions are very dangerous and can burn the skin. They may blind you if they splash into your eyes. Wear rubber gloves and eye protection, and keep the children away. Keep the etch solutions somewhere very safe in glass containers.

The plastic needs to be etched in the solution at about 70 degrees for about 6 hours, but you can experiment to get the right length of time. The easiest way for the barefoot radiation researcher to maintain the temperature at 70degrees for six hours is with a saucepan of water simmering on a stove, and to put the etch solution in a separate container, a glass tumbler for example, resting inside the water in the saucepan. You need a thermometer in the water bath to check that the temperature is roughly constant, and don't forget to keep the water in the saucepan from drying out.

At the end of the etch period, the plastic is removed, washed with water and examined under a microscope to count the tracks in the two different areas, the sample area and the control area. You can use a child's or a student's microscope. Magnification of 100 or less is fine: the tracks can be easily seen. They look like bubbles or stretched out hollow indentations in the plastic surface depending on the angle that the alpha particle was incident on the surface. The presence of a hot particle (e.g. of Uranium or Plutonium) can be seen when the bubbles cluster together as if they originated in a single point somewhere in the middle of the 'star'.

To get a statistically significant count, focus on any part of the exposed part of the plastic (which was in contact with the sample). Count the number of tracks in the field of view. Then move the microscope stage (or the slide) to a new place in the exposed area and make a second count. Do this ten times. Then take the average for the field of view by adding the total number of tracks you found and dividing by ten. Then do the same at the other end of the slide — the control end which was not in contact with the sample. Subtracting the two averages gives a measure of the activity of the sample in alpha tracks per 15 hours, or whatever period you chose to expose the plastic. Now convert this figure to "counts per second" by dividing it by the number of seconds in the exposure period (e.g. 15 x 60 x 60).

This is the activity of only the surface layer, remember. Alpha particles cannot get through all the sample material as they are stopped by a sheet of paper. So if you assume that the surface layer is about 0.2mm thick, you can calculate roughly the alpha activity of the sample. In addition we must recognise that the tracks travel away from their point source or origin in random directions. This means that fewer than half of the alpha decays (even those which originate in the surface layer) will hit the plastic. The actual decay activity will therefore be a bit more than twice what you count. For this reason when calculating the specific area activity you will need to multiply the "counts per second" by two.

To calculate specific area activity, you just have to calculate the number of decays per second per square centimetre. This requires you to calibrate the field of view of the microscope. The easiest way is to use a plastic ruler and focus on the scale. This will give an idea of the radius of the field of view **r**, from which the area of the field of view is just 'pi **r** squared' [3.142 x (**r** x **r**)] . Then the specific area activity (i.e. activity per cm^2) is given by:

Activity = 2 x counts per second/area of field of view

It may be that the background soil type will also have alpha activity, and so to see if the activity you find is suspicious and needs further examination, it is best to also check out some of the soil from nearby: Take a control sample from about 4 inches below an undisturbed surface (one that has not been dug or ploughed or disturbed by an explosion). There will be little chance of this being contaminated by weapons uranium.

For those who want to get the plastic strips, LLRC can supply a pack of 10 pieces of CR39 1 inch by ½ inch for £20. Caustic soda NaOH can be bought at the ironmonger or KOH from chemists, then all you need is a cheap microscope, a thermometer, a saucepan, a small glass tumbler, eye protection, rubber gloves and some kitchen or postal scales that will weigh up to 50grams, accurate to 1 gram.

So there you are. Good luck and good hunting. It is a fascinating endeavour, and the results are very accurate. This is the closest that citizen science gets to the alpha particle. And it is sobering to see these manifestations of the invisible energy carried by the alpha particle decay energy and to reflect on what the energy does to living tissue, given that the hole it smashes in the plastic is equivalent in size to several living cells.

Track Analysis Systems Ltd, H H Wills Physics Laboratory, Tyndall Avenue, Bristol.
BS8 1TL, U.K. Tel: +44 (0)117 926 0353, Fax: +44 (0)117 925 1723
http://www.tasl.co.uk/tastrak.htm   Sales Contact: Dr. Peter Fews; email: info@tasl.co.uk

Low Level Radiation Campaign: email bramhall@llrc.org