I BET YOU DIDN'T KNOW...

The Disastrous Effects of Historical Ink

Dr Craig Early, Fellow of the PSTT College, links **cutting edge research** with the **principles of primary science**

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Iron gall ink is one of the most important inks in the history of Western civilisation and was in widespread use from the middle ages until the 20th Century. It was made from iron salts dissolved in tannic acids that came from vegetables. Unfortunately, when iron is dissolved in acids, such as in these inks, it speeds up the degradation of the paper, thus severely damaging numerous historical artefacts. Initially, the process involves the appearance of brown discolouration on the flip side of the ink lines. Acids in the ink corrode the paper, which eventually results in holes appearing and the paper crumbling. Scientists found that the iron gall inks' pH ranged from pH3.7 (acidic) to pH 7.1 (alkali). This was due to the addition of substances used in the creation of the inks. The acid affects the stability of the cellulose, which was found in high content in early historical rag papers.

Do the children understand what we mean by pH? pH is a scale used by chemists to show how 'acidic' or 'alkali' a solution is. The scale normally goes from 0-14, with 7 being classed as 'neutral'. Anything lower than 7 is acidic, with solutions being more acidic the lower the number. Solutions with a pH higher than 7, are classed as 'alkali', with the higher the value, meaning the more 'alkali' they are. It is useful to point out common acids and alkalis that children will know: vinegar (acetic acid), lemon juice (citric acid) – these are characterised by a sour taste; bicarbonate of soda, soaps, many cleaning products. In the classroom, children could explore and classify a range of common products by making a simple cabbage juice indicator solution and testing the products' effects on its colour.

When science and history meet...

Secondary sources of information provide vital data for reconstructing past history. ***What would happen if we lost all of these valuable documents?***

This is a real-life problem that scientists and historians are having to tackle, with significant parts of cultural heritage having been recorded using iron gall ink. (The composer Bach used it to write down his music, the painter Rembrandt used it for his drawings and the U.S. President Thomas Jefferson wrote the Declaration of Independence with it). Due to the ink's corrosive properties, many documents are starting to show signs of deterioration.

So how can scientists help?

Scientists and historians noticed that not all the historical artefacts degraded at the same rate, and they began to question why. ***What factors do children think could affect the rate at which the paper is degraded by the ink?*** Scientists developed techniques to test what factors they felt

affected the rate of degradation and discovered 3 things which all played an important part. They discovered that width of ink lines, pH of the iron gall ink used on the paper and thickness of the paper were all significant factors. These ideas present wonderful opportunities within the classroom for children's own exploration and investigations.

Ask the children: ***Why do you think this information would be useful for historians and scientists to know?***

An important factor that contributed to historical paper degradation that researchers discovered revolved around the idea of paper thickness or grammage, as it is known, measured in gm^{-2}. The thicker paper meant it took longer for the ink to migrate through and begin to cause damage. The invention of printing in the 15th century led to an enormous increase in the demand of paper, resulting in a significant shortage of old linen, hemp or cotton rags, from which paper was made until the second half of the 19th century. This shortage meant that thinner, low quality paper was produced more often.

In chemistry, absorption rate indicates the speed at which one substance permeates another. The scientists discovered that absorption rate of the ink would determine the rate and level of degradation of the paper. For their investigation, absorption was the time in seconds needed for the paper to absorb 2µl of distilled water. **Children could think about how they could measure absorption rate (e.g. how long before the ink doesn't smudge?). Children could look at the absorption rates of different papers, and investigate: *Which type of paper is better for writing on with ink?*** This could be expanded further to look at brands of toilet and tissue papers, and extend thinking into what we mean by the term "best or better" when investigating papers for different roles.

Electron microscope images of paper also provide an excellent stimulus for discussion, when looking at how the fibres compare from "cheap" to "expensive" brands of paper. Children may wonder: ***What is an electron microscope?*** Microscopes in general magnify things to make them larger, so we can see features about minute or tiny objects in much more detail. Electron microscopes use electron beams in place of light, to allow a much higher magnification and resolution, and to reveal features of even smaller objects.

What is an ink? How are ink and dyes actually made? These are questions that children will naturally have – so why not let them find out? The colours that make up inks and sweet coatings can be separated out simply by using filter paper (readily available) using a process called chromatography, with some incredible results!

References:

The research paper that generated this work was: *Historical iron gall ink containing documents – Properties affecting their condition.*

By Jana Kolar[a], Andrej Stolfa[a], Matija Strlic[b], Matevz Pompe[b], Boris Pihlar[b], Milos Budnar[c], Jure Simcic[c], Birgit Reissland[d], Analytica Chimica Acta 555, 167-174 (2006)

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