Trace element and multi-isotope analysis of human head hair samples

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Introduction: In cooperation with the BKA Wiesbaden, this project is dealing with the investigation of human head hair. The aim of these examinations is to obtain information about the travelling behaviour of a person using spatially resolved analysis of biological samples. The question to be answered is whether it is possible to see a change of someone's habitat through the elemental or isotopic composition of his hair.
For the elemental analysis, several methods are applied: inductively coupled plasma mass spectrometry (ICP-MS), laser ablation-ICP-MS (LA-ICP-MS) and instrumental neutron activation analysis (INAA). Isotope ratio mass spectrometry (IRMS) and thermal ionization mass spectrometry (TIMS) are used for measuring the isotopic composition of carbon, nitrogen, hydrogen, oxygen, strontium and lead in the hair [1].
For each analysis, appropriate sample preparation methods are needed. In the following, only the IRMS method is described in more detail.

Experimental: For IRMS, all of the people who provided hair samples had to fill in a questionnaire concerning their personal height and weight, nutritional habits, hair treatment, and travelling behaviour. In consideration of this information, the hair samples were chronologically segmented. Before hair were divided into sections, the samples were washed in a mixture of methanol and chloroform (2:1). Then, the hair sample sections were homogenised by using a vibrating mill. After freeze-drying the hair, an approximately 0.2 mg aliquot of each sample was weighed in a tin (for C and N) or a silver capsule (for H and O).
For determination of the isotopic ratios of carbon ($^{13}C/^{12}C = \delta^{13}C$) and nitrogen ($^{15}N/^{14}N = \delta^{15}N$), an elemental analyzer (EA) -IRMS system was used (elemental analyzer Flash EA 1112; IRMS Delta V plus, Thermo Fisher Scientific, Bremen). Hydrogen ($^{2}H/^{1}H$) and oxygen ($^{18}O/^{16}O$) ratios were determined by using a high temperature conversion elemental analyser (TC/EA) - IRMS system. The isotope ratios are expressed in delta notation relative to primary international standards (e.g. V-PDB, Vienna Pee Dee Belemnite).

Results: Currently, 30 hair samples which were divided into 113 sections, were analysed by using EA-IRMS. Some of the results are presented in diagram 1 and 2. On axis of abscissae (x-axis) the calendar date is plotted, on the axis of ordinates (y-axis) you can see the isotope ratios of $\delta^{13}C$ (diagram 1) and $\delta^{15}N$ (diagram 2) in delta notation.
The person with the identification number S08/1134/27 travelled from Germany to Kenya for some months. Strand of hair was divided into 6 sections. The highest isotope ratio is detected at the time while that person was living in Kenya ($\delta^{13}C$ = -19.19 ‰; $\delta^{15}N$ = 10.22 ‰, marked in blue, ▲). The sections which reflect the period in Germany shows lower isotope ratios (marked in orange, ◆). The green marked section (■) presents the change between Germany and Kenya. Errors in the diagrams are defined to 0.2 ‰.

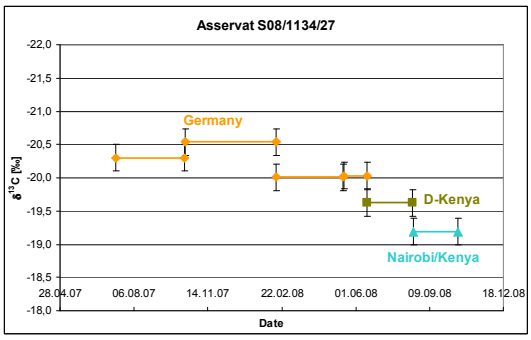

Diagram 1: Carbon isotope ratios ($\delta^{13}C$) of person S08/1134/27 are presented here. The person travelled from Germany to Kenya. Orange marked rhombuses (◆) reflect the time period in Germany; blue marked triangles (▲) show the time in Kenya. The green marked quadrangles (■) presents the change between Germany and Kenya.

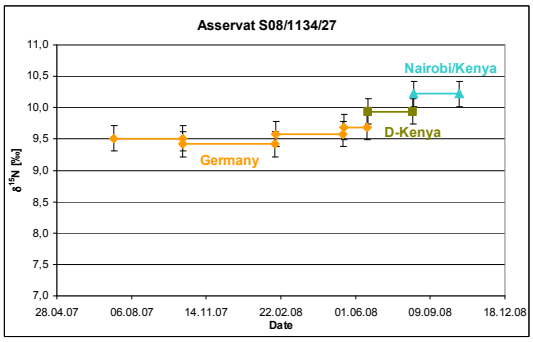

Diagram 2: Nitrogen isotope ratios ($\delta^{15}N$) of person S08/1134/27 are presented here. The person travelled from Germany to Kenya. Orange marked rhombuses (◆) reflect the time period in Germany; blue marked triangles (▲) show the time in Kenya. The green marked quadrangles (■) presents the change between Germany and Kenya.

Conclusion: For all analytical techniques mentioned above, sample preparation methods were developed and first tests were realised. By using ICP-MS, LA-ICP-MS, and INAA, the elemental composition of hair samples could be determined. Also, the results of IRMS and TIMS are promising. Thus, these analytical methods seem to be suitable for the investigation of human head hair.
In the future, further analyses of more hair samples will be performed. Still, the development of an adequate interpretation method for the results will be a major task.

References

[1] Mützel, E., Lehn, Ch., Peschel, O., Hölzl, S., Roßmann, A., 2009. Assignment of unknown persons to their geographical origin by determination of stabile isotopes in hair samples, Int J Legal Med 123, 35-40.

Acknowledgement

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