Determination of heavy metals in human teeth using instrumental neutron activation analysis (INAA)

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Neutron activation analysis in combination with high-resolution gamma ray spectrometry is a versatile method for various analytical problems due to its simplicity, multielement capacity, and sensitivity. The instrumental neutron activation analysis (INAA) is performed without any chemical separation steps, whereas the radiochemical neutron activation analysis (RNAA) applies chemical procedures either prior to or after the neutron irradiations.

INAA is being used to determine the concentration of the heavy metals Mn, Mg, Al and Zn in human teeth, while for a determination of Fe the RNAA is necessary.

Due to high beta background mostly produced by the radioactive isotopes of calcium and phosphorus, the irradiation time and the irradiation position were modified in order to obtain the optimal conditions for the analysis of each trace element.

For the determination of Mg and Al the samples were irradiated in the Rabbit system with a neutron flux of $1.7 \cdot 10^{12}$ n/(cm^2 · s) for 30 seconds. After 5 minutes cooling time, the samples were analyzed using the gamma spectrometry.

For the analysis of Mn the samples were irradiated in the Rabbit system for 2 minutes. After two hours cooling time, the samples were analyzed.

In the case of Zn the samples were irradiated in the Rotary specimen rack with a neutron flux of $0.7 \cdot 10^{12}$ n/(cm^2 · s) for 6 hours. After one week cooling time, the samples were analyzed. The irradiation conditions are summarized in table 1.

First, the process was applied using as samples pieces of teeth. In order to obtain a mean value and the variation of the trace element concentration 20 pieces of tooth were irradiated for the determination of Zn, 56 for the determination of Mn and until now 6 for the determination of Mg and Al. The results and the literature values are summarized in table 2. Fig. 1 shows the measured values for Zn.

To study the different heavy metal concentrations in the dentine and the enamel, a flotation method to separate both parts was chosen. For that, the whole tooth must be ground to a fine powder. To demonstrate that the used device will not contaminate the samples new NAA measurements are being performed using this tooth powder.

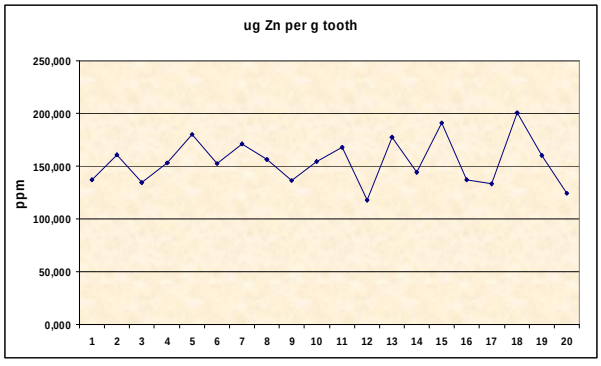
Table 1: Irradiation conditions

Element	Irradiation time	Irradiation position	Cooling time	Measuring time
Mg	30 s	Rabbit system	5 min	5 min
Al	30 s	Rabbit system	5 min	5 min
Mn	2 min	Rabbit system	2 h	30 min
Zn	6 h	Rotary specimen rack	1 week	1 h

Table 2: Concentrations of heavy metals in teeth

Element	Amount (mg / kg tooth)		
	Results	Literature	
		Dentine	Enamel
Mg	4590 - 5570	3000 - 11100	1000 - 4100 (Average)
Al	850 - 880	62 - 136	16 - 2304
Mn	0.13 - 1.29	0.4 - 20	0.09 - 25
Zn	118 - 201	50 - 999	100 - 702

Fig. 1: Measured concentrations of Zn in teeth in µg Zn per g tooth



References

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