

The content of lead, cadmium, zinc and copper in deciduous and permanent human teeth

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The aim of the study was to compare the uptake of the trace metals lead, cadmium, zinc and copper, in deciduous and permanent teeth. The material consisted of teeth extracted in the Oslo area. The teeth were digested in hydrochloric acid, and analyses were made by differential pulse stripping voltammetry. Similar levels of cadmium and zinc were found in deciduous and permanent teeth. The copper content varied little in deciduous teeth, but in permanent teeth a wide variation in the copper levels was found. The content of lead in deciduous teeth was found to be higher than in permanent teeth.

Key-words: Lead; cadmium; zinc; copper; trace elements

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During the last years, increasing interest has been focussed upon the accumulation of heavy metals in the human body caused by a growing environmental contamination. Some of these metals, such as zinc and copper, are known to be essential trace elements which participate in specific metabolic functions and as constituents of several enzymes. Others, such as lead and cadmium, are regarded to be non-essential and to exert only toxic effects in biological systems. They are serious hazards to human health due to their increasing presence in the environment. Thus the level of lead in snow layers from Greenland and the Antarctic reveals a rapid increase in atmospheric pollution (Murozumi, Chow & Patterson, 1969). Likewise, lead levels in ocean waters have been increasing, mainly caused by addition from rain water (Tatsumoto & Patterson, 1963). This accelerating pollution is most

likely caused by the use of lead-containing petrol.

Cadmium, although being widely distributed in Nature, is occurring naturally in man's environment in insignificant amounts compared to major sources of contamination like the smelting and refining of zinc and lead ores, the combustion of oil and coal, and the disposal of waste plastics and sewage sludge.

The elevated levels of trace metals in most tissues caused by ingestion of the metals vary according to length and intensity of exposure. Such levels are often indicating present exposure only, because a decline occurs once ingestion is reduced. Several reports have, however, pointed out that teeth are suitable indicators of past exposure to such metals, both because their physical stability causes the metals to be retained, and because teeth are well suited as biopsy material in a population

(Altshuller *et al.*, 1962; Needleman, Tuncay & Shapiro, 1972).

The present study has utilized teeth to determine the exposure of children and adults to the trace metals lead, cadmium, zinc and copper.

MATERIALS AND METHODS

Teeth. The teeth were collected from patients treated at the Department of Oral Surgery and Oral Medicine at the Dental Faculty, University of Oslo. Deciduous teeth and permanent premolars extracted for orthodontic reasons were also obtained from dental school clinics in Oslo. Only caries-free teeth or teeth with minor cavities were used for analysis. Filled teeth were excluded. After extraction, the teeth were allowed to dry, and thereafter stored in paper bags.

Solutions. Double glass distilled water was used throughout the study. All reagents were of suprapur quality (Merck). Sodium acetate buffer, 0.1 M, pH 4.7, was used as electrolyte and solvent for the digested tooth material.

Preparation of samples. The teeth were weighed and dissolved in 5 ml hydrochloric acid in polyethylene vials. After complete digestion, the solution was dried by heating to 100°, and the residue was redissolved in acetate buffer to make the initial tooth weight 10 per cent of the solution (w/v).

Apparatus. The samples were analyzed by differential pulse stripping voltammetry (Princeton Applied Research, Model 174 Polarographic Analyzer). The instrument was worked at a scan rate of 5 mV/sec., drop time 0.5 sec., modulation amplitude 50 mV and a current range between 0.02 and 0.2 mA. The initial potential was set at -900 mV for the lead, cadmium and copper analyzes, and at -1300 for the zinc

analyzes. A Metrohm E 410 hanging mercury drop electrode was used as working electrode, with a Metrohm EA 427 reference electrode. To avoid contamination of the samples, the reference electrode was placed behind a sintered glass bridge containing acetate buffer. The electrolyte cell (Metrohm EA 875) was siliconized, and the sample was stirred by a teflon-covered magnetic bar.

Analysis. 2.5 ml of the tooth digest solution was added to 7.5 ml acetate buffer in the electrolyte cell, highly purified nitrogen was bubbled through the cell while the magnetic stirrer was operated at 60 r.p.m. After 10 minutes, a fresh mercury drop was extruded, and the electrode was plated for 3 minutes. Thereafter the nitrogen supply was cut, and the stirring stopped. After a rest period of 15 sec., the stripping voltammogram was recorded. The metal concentration was determined by the method of standard addition. 25 and 50 μ l samples of standards were added to the electrolyte cell, and the plating and stripping procedure repeated.

To test the reproducibility of the method, nine teeth were digested. Each digest was divided in two and prepared for analysis separately. The variation between the parallels was 6.3 per cent (S.D.) for the Pb analyzes, for Cd, Zn and Cu the variation was less than this value.

The tooth material concentration in the test samples was found to interfere with the Zn readings, possibly through complexing effects. After standardizing the tooth material concentration to 10 per cent in the test samples, linearity was found between added Zn standards to the samples and meter readings, within the concentrations encountered in the samples.

The analyses of one metal was not influenced by the addition of the other metals to the test sample.

Table I. The content of Pb, Cd, Zn and Cu in deciduous teeth ($\mu\text{g/g}$)

	n	range	\bar{x}
Pb	32	1.5 — 13.4	5.6
Cd	16	0.04— 0.24	0.10
Zn	16	91—180	130
Cu	13	0.20— 0.64	0.45

Table II. The content of Pb, Cd, Zn and Cu in permanent teeth ($\mu\text{g/g}$)

	n	range	\bar{x}
Pb	44	0.9 — 7.8	2.4
Cd	19	0.03— 0.51	0.10
Zn	18	79—270	130
Cu	18	0.20— 4.40	1.1

Differential pulse stripping voltammetry may be used at a very high sensitivity. The method and instrument settings employed in the present study gave a detection limit of about $0.01 \mu\text{g Cd}$, $0.1 \mu\text{g Pb}$ and Cu , and $0.5 \mu\text{g Zn}$ per g tooth material.

RESULTS

The distribution of the trace metals in deciduous and permanent teeth is shown in Tables I and II, and in Figs. 1 to 4. The content of lead and copper is seen to differ between deciduous and permanent teeth; the lead level being higher and the copper level lower in deciduous teeth. The content of copper in permanent teeth showed a wide variation. The distribution of cadmium and zinc was found to be similar in the two groups.

When the data of the lead content in permanent teeth were arranged according to decade of life and tabulated, no definite trend was found. Neither was any difference found between erupted and unerupted teeth.

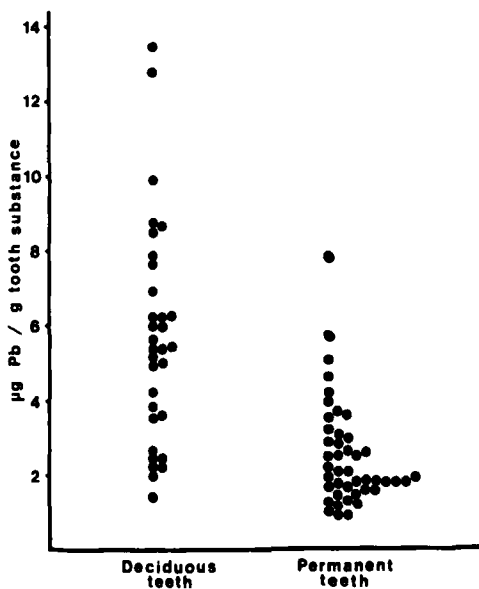


Fig. 1. Lead levels in deciduous and permanent teeth.

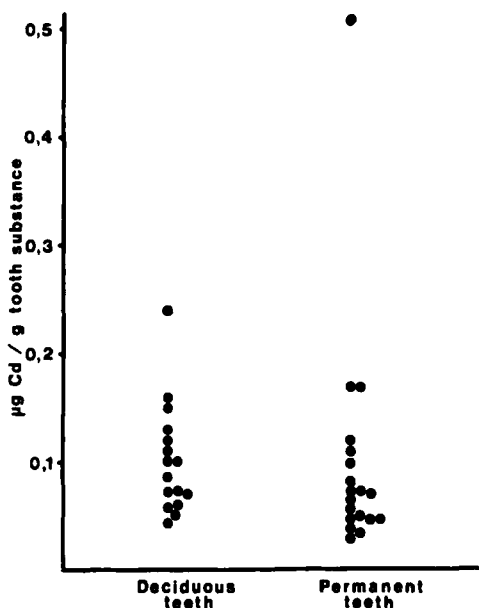


Fig. 2. Cadmium levels in deciduous and permanent teeth.

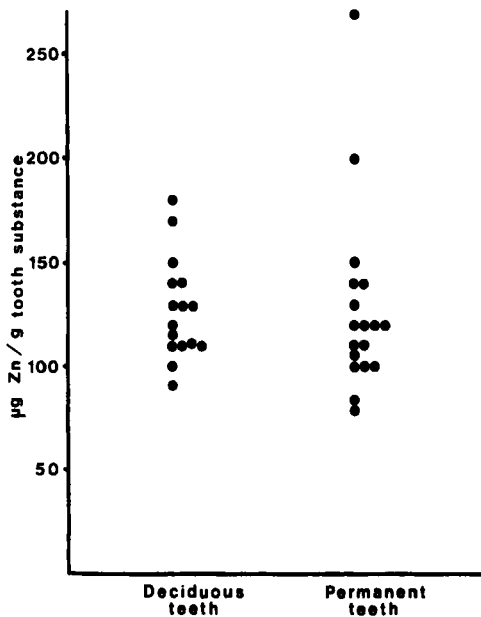


Fig. 3. Zinc levels in deciduous and permanent teeth.

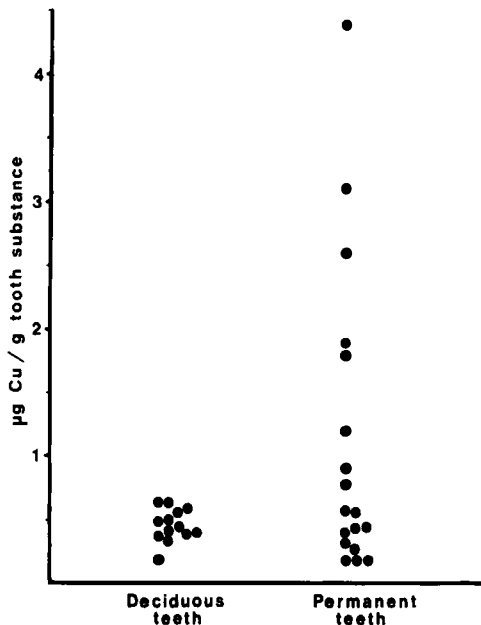


Fig. 4. Copper levels in deciduous and permanent teeth.

DISCUSSION

This study was undertaken with the purpose of comparing the trace metal uptake of deciduous and permanent teeth.

The lead pollution of man's environment has gradually become a matter of general concern. Atmospheric lead aggregates to particles which sediment (Gillette, 1972). It is conceivable that children might be more exposed to these aggregates due to their lesser height. It has recently been pointed out that urban street dust may easily be a potential lead source of 100—1000 µg daily for children (Day, Hart & Robinson, 1975). Additionally, lead-based paints constitute an urgent danger for children, there may thus be reason for particular attention of the lead uptake of children.

The deciduous teeth have been used as an indicator of lead intake in children (Altshuller *et al.*, 1962). Our results showed a higher lead level in deciduous teeth than in permanent teeth. Provided the uptake mechanism is similar in permanent and deciduous teeth, and provided that the major part of this uptake occurs before tooth eruption, the findings would indicate that children are more exposed to lead during the first years of life than at a later age. The lead levels found in the present study are low compared to those given in most studies reported (Needleman *et al.*, 1972; Brudevold & Steadman, 1956). Against this background it is interesting to note that Shapiro *et al.* (1973) found a level of lead in the dentine of deciduous teeth in Icelandic subjects very similar to our findings.

Cadmium is virtually absent in newborn, but accumulates with age in the kidney (Perry *et al.*, 1961). The literature contains scant information on the cadmium content of deciduous and permanent teeth. Leices-

ter, Thomassen & Denzler (1953) reported uptake of radioactive cadmium in enamel, but not in dentine, after oral administration. In an analysis of 14 permanent teeth Langmyhr, Sundli & Jonsen (1974) found a cadmium content varying between 0.07 and 2.2 $\mu\text{g/g}$. Our results suggest no difference in the cadmium uptake of deciduous and permanent teeth.

Copper has been found in teeth at a level of 9.5–11.3 $\mu\text{g/g}$ (Nixon & Smith, 1962). Observations by Nixon & Helsby (1973) indicate that the copper uptake of teeth is related to the copper intake. Our findings demonstrated a very wide range of the copper content of permanent teeth, but even so, the average copper content of both deciduous and permanent teeth was low.

Zinc, being one of the most abundant essential trace elements in the human body, has been reported from a level of between 1 and 4 $\mu\text{g/g}$ of whole teeth (Wilkinson & Palmer, 1975) and up to 2000 $\mu\text{g/g}$ in the surface regions of the enamel (Brudevold & Sørenmark, 1967). The zinc content of enamel has been found to vary in different geographical areas (Brudevold & Sørenmark, 1967), a finding which indicates an uptake determined by dietary zinc levels. In the present study, similar levels of zinc was found in deciduous and permanent teeth.

In conclusion, amongst the four trace metals included in our study, lead was the one which had the most significant different uptake in deciduous and permanent teeth. The results thus suggest that the lead burden of children is more pronounced than that of adults, and further research should be aimed at elucidating the nature of this exposure.

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