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Determination of fluoride, zinc and lead ions concentrations in primary teeth and drinking water and dental caries experience

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ABSTRACT

Aims: To detect the levels of fluoride (F), zinc (Zn) and lead (Pb) in primary teeth and drinking water and their relation to dental caries experience in school children aged 6–12 years living in two distinct areas in Ninevah Governorate using two different sources of drinking water supply. **Materials and Methods:** The samples consisted of 120 freshly extracted highly mobile free of dental caries human primary mandibular teeth and ten wells water samples with ten tap water samples which had been chosen randomly. The samples were analyzed for F by fluoride sensitive electrode and for Zn and Pb by computerized atomic absorption spectrophotometer. Assessments and recording of caries experience were done by application of decayed, missing and filled surfaces (dmfs) index for primary dentition. **Results**: Statistical analysis of the results indicated that the mean F and Zn concentrations in the teeth were 244.35 $\pm$ 167.49 ppm; 87.41$\pm$ 36.64 ppm respectively of the rural children were significantly higher than in the teeth of urban children (104.53 $\pm$ 52.75 ppm; 65.19$\pm$ 28.79 ppm respectively). Meanwhile the concentration of Pb in the teeth of the urban children (1.62$\pm$0.41 ppm) was significantly higher than in the teeth of rural children (0.94$\pm$ 0.80 ppm)($p<0.001$). Statistically significant higher F concentration in the wells water (3.39$\pm$ 0.25 ppm) than urban water supply (0.19$\pm$ 0.07 ppm) ($p<0.001$). Statistically significant higher Zn concentration in the urban water supply (0.1.34$\pm$ 0.31 ppm) than wells water (0.07$\pm$ 0.03 ppm) ($p<0.001$), but Pb concentration in wells water was not detected. Statistically significant higher caries experience was found in urban children than in rural ($p<0.001$). In the rural and urban areas, a negative correlation in the dmfs with F and Zn concentrations in teeth while a positive correlation with Pb was observed. **Conclusions**: A highly significant F and Zn concentrations in primary teeth were found in rural area than the urban and the opposite was true for Pb concentration. High significant F concentration was found in the wells water than urban water supply, and the opposite was true for Zn, but Pb concentration in wells water was not detected. High significant **differences** in dental caries indices were found in urban children than in rural children.

Key Words: Fluoride, zinc, lead.

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INTRODUCTION

Trace elements are variously defined depending upon the study field of chemical, physical, or biologic sciences. In the field of biology, elements that are present in only minute quantities in animal tissues are called trace elements, regardless of their abundance in nature. Thus, to biologist silicon and fluorine (among the most plentiful of the elements in the earth's crust) are trace elements.[1]

Essential trace elements play a major role in health, the deficiency of them cause disturbances in metabolism and growth of tissues and even minute portions of them can powerfully affect health,[2] while the non–essential trace elements are harmful even in trace amounts for humans.[3]

Trace concentrations of fluoride (F) in drinking water undeniably reduce dental caries.[4] Epidemiologic studies indicate that even in areas where the water has a low F concentration and the dietary habits are similar, the prevalence of caries may vary widely, possibly owing to differences in other trace elements ingested.[5] The trace elements intake of man is via a soil–water–plants–animal food chain.[6]

Zinc (Zn) is essential for the function of the human body and deficiency as well as excess of Zn may be harmful. The role of increased Zn intake as a caries preventing agents still need to be properly studied. Data from many human studies are equivocal, and it is not clear whether Zn increases or decreases caries. It is possible that Zn may do both, depending on its concentration.[7] Tvinnereim *et al*., [8] found that Zn concentration in carious teeth was 27% higher than in non–carious teeth and tooth Zn varied significantly with caries status. El–Samarrai [9] found that Zn in the permanent teeth was seen to decease in concentration as the number of carious surfaces increase.

Lead (Pb) has no known physiological functions and is toxic even in low concentrations.[10] Data from several epidemiological and experimental studies support the concept that Pb is a caries promoting element.[11,12] The possible mechanism through which Pb could enhance susceptibility to caries had been suggested that Pb had a divalent cation, its metabolism is affected by the same factors that affect calci-um metabolism, and Pb has tendency to "folow the calcium stream" Pb ions apparently act directly on bone mineral to replace calcium and phosphorus in the crystal lattice, making the enamel more susceptible to dissolution and initiation of caries process.[13, 14]

The aims of the study were to assess the trace elements F, Zn and Pb concentrations in primary teeth of school–age children of rural and urban area; determine F, Zn and pb concentrations in two different sources of wells and communal drinking water supply; identify if there is relation between the caries experience and elements concentrations in the primary dentition and assess the effect of elements concentrations in drinking water supply on the caries experience in school–age children.

MATERIALS AND METHOD

F, Zn and Pb levels in the drinking water and the primary teeth of 6–12 years old school children living in two distinct areas in Ninevah Governorate were measured. The first is a rural area including two villages, Shakoli and Sheek Kh-amer, which are near to each other in Al-Hamdania Province in which the wells are the only source of drinking water and the second area is Mosul City Center with communal water supply from Tigris River. The samples consisted of one hundred and twenty, freshly extracted, highly mobile, free of dental caries, human primary mandibular teeth (sixty teeth from each study area) and ten wells water samples (five from each village) and ten drinking water (tap water) samples of communal water supply of Mosul City Center (five from the right side and five from the left side of the city) which were chosen randomly.

After getting the approval of the Directorate General of Education of Ninevah Governorate to visit and examine the students in the primary school, two primary schools in Mosul City, had been chosen randomly, in addition to Shakoli and Sheek Khamer primary schools.

All school children were examined and after receiving a signed parents' agreement to extract the indicated tooth, clinical examinations of teeth were conducted using mirror and sharp dental explorer. Prior to teeth examination, they were cleaned with cotton and dried with manual air syring. Caries experience through numbers of affected surfaces of the teeth were assess-ed and recorded by the application of dec-ayed, missing and filled surfaces (dmfs) index for deciduous teeth.[15]

The preparation of teeth samples was done according to the method described by Lappalainen and Knuuttila.[16] Teeth were polished first with a slurry of non–fluoridated pumice and white rubber prophylactic cup using a slow speed hand piece, then washed thoroughly by deionized water. Teeth were dried at 105°C for 6 – 8 hours by using hot air oven till they reach constant weights. Then the teeth samples powdered using ceramic mortar and pestle. Samples of 100 mg of tooth powder were dissolved in 0.8 ml of concentrated hydrochloric acid and 0.4ml of concentrated nitric acid. Following dissolution of samples, dilution with 2ml deionized water was done and then filtered by the use of pre–weight filter paper. The volume then was completed by addition of deionized water using glass pipette to reach a final volume of 10ml. The filter paper was re–weighted again following dryness and the difference from the original weight subtracted from 100mg and the final weight of the dissolved tooth powder in 10ml was determined.

Drinking water samples were collected in cleaned transparent screw-top polyethylene bottles. Wells water were taken directly from the well while prior to sampling tap water, the tap water was run for 1–2 minutes to obviate any high result arising from standing water.(17) Two to three drops of nitric acid were added to the water samples to prevent the loss of metals from the solution, Water samples were analyzed in a straight forward way without any further treatment and the analysis was carried out the day after the samples were collected.(18)

The F ion concentration was determined using a F ion sensitive electrode, coupled with a digital PH/Ion meter.

The samples were analyzed for Zn and Pb by computerized air–acetylene atomic absorption spectrophotometer (AAS).

Data was collected and analyzed by using descriptive statistics (mean, standard deviation) and inferential statistics include; Student's t–test and Z–test for testing the significant differences between two different groups and Spearman's Correlation was used for measuring correlation coefficient between caries experience and trace elements concentrations in the primary teeth. Probability (*p*) at 0.05 level was considered as statistically significante.

RESULT AND DISCUSSION

Tables (1) illustrated that F concentration was higher in primary teeth of rural children (244.35 ± 167.49 ppm) than in the teeth of urban children (104.53 ± 52.75 ppm) with significant differences (p <0.005) and F level in the drinking wat-er supply of the rural area (3.38 ± 0.25 ppm) was higher than in the drinking wat-er supply of the urban area (0.19 ± 0.07 ppm) with significant differences (p<0.005) as seen in Table (2).

Table (1): Comparison between Values of Floured, Zinc and Lead in Primary Teeth from Rural and urban area.

Parameters	Area of residence: Mean ± SD (ppm)		t–teast	*P*–value
	Rural (60)	Urban(60)		
Fluoride	244.35 ± 167.49	104.53 ± 52.75	5.098	Significant
Zinc	87.41 ± 36.64	65.19 ± 28.79	4.488	Significant
Lead	0.94 ± 0.80	1.62 ± 0.41	4.321	Significant

SD: Standard deviation

Table (2): Mean and Standard Deviation of Fluoride, Zinc and Lead concentrations in drinking water supply according to area of residence.

Parameters	Area of Residence: Mean ± SD (ppm)		t–teast	*P*–value
	Rural (10)	Urban (10)		
Fluoride	3.38 ± 0.25	0.19 ± 0.07	9.242	Significant

Zinc	0.07 + 0.03	1.34 + 0.31	7.243	Significant
Lead	Not detected	0.0098 + 0.0005	--------	---------

SD: Standard deviation

This agreed with Carvalho *et al.*,[19] who found significantly higher F level in teeth of children living in highly fluordated area than non fluoridated one.

Zinc concentration was higher in the teeth of rural children (87.41 + 36.64 ppm) than in the teeth of urban children (65.19 + 28.79 ppm) with significant differences (p<0.005). These results indicated that in rural area the children intake of food sources that rich in Zn supply is more which is of animal origin that may be attributed to the life style of rural people who depend on themselves in raising animals.

While the opposite was true for Pb concentration that's higher in the teeth of urban children (1.62 + 0.41 ppm) than in the teeth of rural children (0.94 + 0.80 ppm) with significant differences (p <0.005).

This agreed with other previous studies [20, 21] which found that the urbanization increase Pb concentration in teeth.

Table (2) demonstrated that statistically high significant differences were found in the concentration of F in rural wells water (3.38 + 0.25 ppm) than urban drinking water (0.19 + 0.07 ppm) (p<0.005), this may be contributed to the differences in the nature of water sources of both areas. This result in agreement with previous study conducted by Zelewski *et al*,[22]

While the concentration of Zn in urban drinking water (1.34 + 0.31 ppm) was hi-gher than rural wells water (0.07 + 0.03 ppm), with significant difference (p <0.005). This may be explained that Zn was belong the category of mineral tap water contamination and high Zn concentration in urban drinking water can be attributed to corrosive nature of the water in the distribution pipes and water tanks.[23]

Drinking water is one of the main pathways by which Pb can reach the body. Drinking water contaminated by lead through lead pipes or industrial waste products.[24] Lead concentration in urban drinking water was 0.0098 + 0.0005 ppm, meanwhile Pb concentration in rural wells water was not detected or can say it was less than 0.008 ppm. Because the detection limit of AAS that used in Pb analysis was 0.008 ppm, that agreed with Dix[25] who demonstrated that the wells water in rural areas generally found to be away from industrial waste products.

Table (3) showed that statistically high significant differences between dmfs values of the rural and urban children were found (p<0.001). These results agreed with Al–Azawi [26] and Ali,[27] who found that the prevalence and intensity of dental caries were more in urban area than in rural area.

Table (4) demonstrated that F level in teeth show a negative correlation with dmfs index and its fractions in both area of residence. It reached a high significant level with dmfs and ds in the rural area only.

These results agreed with previous study which found that F has a remarkable effect on caries prevention and increase levels of F in teeth associated with reduced level of dental caries and its severity.[19]

Also the result showed that, in the rural area, Zn levels in teeth found to have negative correlation with caries (significantly with dmfs and ds).This agree with El–Samarrai [9] and disagreed with Tvinnereim *et al.*,[8] who demonstrated that Zn have a positive correlation with caries.

Table (3): Caries experience of primary teeth among children according to the Area of residence.

Parameters	**Mean + SD**		**Z–test**	***P*–value**
	Rural (60)	**Urban(60)**		
ds	4.38 +3.06	13.45+ 7.68	9.411	Significant

ms	3.50± 3.70	6.79 ± 5.72	4.558	Significant
fs	0.0	0.0	----------	---------
dmfs	7.92± 5.28	20.24± 10.74	9.021	Significant

ds: Decayed surfaces. ms: Missing surfasces. fs: Filled surfaces. dmfs: Decayed, missing and filled surfaces. SD: Standared deviation

Table (4): Correlation coefficient between trace element concentrations in primary teeth and dmfs according to area of residence**.**

Area of Residence	Caries experience	Fluoride	Zinc	Lead
Rural	dmfs	–0.462**	–0.194*	0.395*
	ds	–0.462**	–0.274*	0.516*
	ms	–0.183	–0.123	0.241
	fs	0.0	0.0	0.0
Urban	dmfs	–0.400	–0.434	0.550**
	ds	–0.224	–0.304	0.331**
	ms	–0.339	–0.267	0.451**
	fs	0.0	0.0	0.0

* Significant at *P*< 0.05. **High significant at *p*< 0.01.

The negative correlation of Zn with caries may be attributed to the powerful cariostatic effect of F that is found in higher concentration in the rural teeth than the urban teeth, Which alone is responsible for low caries in the rural chil-dren and not necessarily be due to the presence of Zn.

In this study, Pb in the teeth found to be positively correlated with dmfs in-dex. These results agreed with previous studies[8, 12] which found that the increase in the levels of Pb in teeth were associated with increase level of dental caries and its severity may be due to Pb ability to inhibit or mimic the actions of calcium (which can affect calcium–dependent or related processes) and to interact with proteins making the enamel more susceptible to dissolution and initiation of caries process.

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Tables (2) and (3) illustrated that high significant difference in the level of F in wells drinking water (3.38 ± 0.25 ppm) than the urban drinking water (0.19 ± 0.07 ppm) may be responsible for the high significant differences in the value of dmfs in the urban area (20.24 ± 10.74 ppm) than rural area (7.92 ± 5.28ppm) (*p*<0.001). These results agree with Carvalho *et al.*,[19] who found that the water–borne fluride has been established to be the singlemost important factor for the control of dental caries in populations.

High significant difference in the level of Zn in urban drinking water (1.34 ± 0.31 ppm) than wells drinking water (0.07 ± 0.03 ppm) may be respons-ible for the high significant differences in the value of dmfs in the urban area (20.24 ± 10.74 ppm) than rural area (7.92 ± 5.28 ppm) (*p*<0.001). These results agree with Curzon and Bibby [28] who carried a small epidemiologic study which revealed that zinc was associated with increased caries, since Zn considered being belong the contamnant water variables. While disagreed with Gauba *et al.*,[5] who failed to find any dife-rences in the prevalence and severity of de-ntal caries in the children of three rural are-as with different Zn levels in the drinking water.

Higher Pb level in urban drinking water (0.0098 ± 0.0005 ppm) than wells drin-king water (which is not detected) with hi-gh significant differences in the value of dmfs in the urban area (20.24 ± 10.74 ppm) than rural area (7.92 ± 5.28 ppm) (p<0.001). These indicated toward the cari-ogenic role of Pb which agreed with Bowen [29] who found a strong positive correlation between caries pre-valence and concentration of Pb in drin-king water.

CONCLUSIONS

A highly significant F and Zn conce-ntrations in primary teeth were found in ru-ral area than the urban and the opposite was true for Pb concentration.

High significant F concentration was found in the wells water than urban water supply, and the opposite was true for Zn, but Pb concentration in wells water was not detected.

High significant differences in dental caries indices were found in urban children than in rural children.

Different correlations were obtained between elements concentration in teeth and caries experience values studied by number of affected surfaces.

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