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Consumption of Heavy Metal and Minerals by Adult Women through Food in Sewage and Tube -Well Irrigated Area around Ludhiana City (Punjab, India)

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ABSTRACT A dietary survey was carried out during summer and winter seasons on 20-40 years old subjects i.e. 23 and 49 women from sewage and tube well irrigated areas, respectively around Ludhiana city (Punjab, India). Raw food samples from both the areas were analyzed for various minerals. Mineral intake by individual subjects were calculated from the amount of food consumed and mineral contents of foods. The data revealed that intake of lead by women in sewage irrigated area was almost twice the amount compared to women from tube well irrigated area. However, intake of lead was below the maximum tolerable limits, except by women in sewage irrigated area during summer season. Intake of cadmium in both the areas was 2-3 times higher than the prescribed tolerable limits in sewage irrigated area. The intake of nickel was higher by women subjects in sewage irrigated area , however, intake of nickel in both the areas was much below the maximum tolerable limits. Intake of copper was much higher than ICMR's suggested values while that of zinc was comparable to allowances in both areas. Manganese values were significantly higher in women from tube well irrigated area while that of iron was more in women from sewage irrigated area. Mineral intake reflected the mineral content of the foods consumed, because the mineral content of most vegetables was higher in sewage irrigated area except for manganese and zinc. Mineral content of drinking water was not much different.

INTRODUCTION

Modern civilization is completely dependent on a large range of metals for all aspects of daily life. There is a long history of association between metals and human development (Encyclopedia Britannica, 1980). Heavy metal constantly interplay with human life environmentally, industrially and biologically. The toxicity resulting from the continuous and excessive exposure of heavy metals poses a grave risk factor to human health as pathological changes have been observed in the kidney, liver, gastrointestinal tract, bone, pancreas, testes, blood vessels etc. (Hunt et al., 1991). The city of Ludhiana (Punjab, India) has large number of industries like cycle, cycle parts, sewing machine, textiles, dyeing etc. and effluents from these units is thrown into sewage system without much treatment. Municipal sewage is partly used for irrigation purposes in fields of nearby villages. The crops grown in such areas are vegetables and among these leafy vegetables and root crops accumulate large amounts of Zn, Cu, Pb and Cd than those from tube well irrigated soils (Abdulla et al., 1995 and Setia et al., 1998).

The population living around Ludhiana city in the sewage irrigated area is likely to consume high amounts of toxic heavy metals in their daily diets which may put them at health risks. Therefore, the present study was carried out to determine the intake of heavy metals and minerals through food by adult women in sewage irrigated area in comparison with their counterparts residing in the tube well irrigated areas.

MATERIALS AND METHODS

To study the intake and subsequent influence of heavy metals and minerals in women, 40 females from Tube well irrigated area i.e. three villages namely Pohir, Thakkarwal and Ayali Kalan and 23 females from Manna Singh Colony, Chander Nagar and Chhauni Mohalla which comprised sewage irrigated were selected for the study. All the subjects were in the age group of 20-40 years. The dietary survey of the subjects was carried out using '24 hour recall-cum-weighment' method both during winter and summer seasons. From the amount of cooked food consumed, raw foods consumed by individuals were calculated using standardized utensils.

To determine the mineral intake by the subjects, fresh samples of water and milk and the raw samples of cereals, pulses, vegetables and other foods consumed were collected from both the areas during summer and winter seasons. For each food item, five samples were collected from each area. All food samples were dried and analyzed for minerals (Pb, Cd, Ni, Mn, Fe, Cu, Zn and Ca) after wet digestion using diacid mixture (Nitric acid : Perchloric acid :: 9:1) using atomic absorption spectrophotometer. From the amount of food consumed and average mineral content of various foods, mineral intake by individual subjects was calculated. Mineral intakes were compared with the recommended/ suggested/ safe levels of intake for each mineral. The data were analyzed for differences in intake both for seasonal and area- wise variations using F-test.

RESULTS AND DISCUSSION

The data for intake of lead, cadmium, and nickel by women in both the areas during summer and winter seasons presented in Table1, revealed that lead intake was more during summer season compared to winter season in both the areas. Though average lead intake during summer by women in sewage irrigated area was more than the tolerable limits of 430 µg/ day suggested by WHO (1972). The overall intake during summer season was higher but intake during winter season was lower than the above mentioned limit. Average intake of lead by women in sewage irrigated area was almost double the values noticed in tube well irrigated area, the differences being significant ($P<0.05$). Lead was not detected in drinking water, wheat flour and rice of both the areas. Almost all vegetables and cattle milk from sewage irrigated area had higher lead content than those from tube well irrigated area. Sharma and Kansal (1986) also reported that the food materials collected from sewage irrigated soils always contained higher amounts of heavy metals. The concentration of Cu, Zn, Cd and Pb in the crops was higher when the soils received waste water from the industrial towns. But Fe and Mn concentrations were generally higher in the crops getting waste water from non-industrial town. This might be due to the antagonistic effect of other elements on Fe and Mn (Singh, 1981). An earlier study from this institute indicated that the lead intake in sewage irrigated area was six times higher than that in tube well irrigated area (Ahuja, 1997). Steps taken by local Public Health Department might have resulted in lower intake of lead which also included safe water supply in the area.

As seen from the data in Table 1, cadmium intake was significantly more during summer as compared to winter season in both areas. However, in both the regions, intake of cadmium was 2-3 times higher than the maximum tolerable limit of 65 µg/ day (WHO, 1989). Intake of cadmium by women of sewage irrigated area (138.95 µg/day) was significantly higher than those from tube well irrigated area (128.25 µg/ day). Similar high cadmium intake (264 µg/ day) has been reported in an earlier study in sewage irrigated area (Ahuja, 1997).

Consumption of nickel in both the areas (Table 1), was between one-third to one- fourth of the maximum tolerable limit of 600 µg/ day suggested by WHO (1989). Nickel intake by women of tube well irrigated area was significantly lower ($p<0.05$) than their counterparts in sewage irrigated area. Slightly higher intake of nickel was observed during summer as compared to winter in sewage irrigated

Table 1: Average daily intake of Pb, Cd and Ni (ig/day) by women of sewage and tubewell irrigated areas around Ludhiana city (Punjab).

Area	*Lead*	*Cadmium*	*Nickel*
SIA, n=23			
Winter	233.51±52.19	129.47±6.34	157.42±18.44
%Adequacy	54	198	26
Summer	635.68±51.95	148.43±8.16	214.95±15.15
%Adequacy	148	228	36
F-Ratio	81.37*	9.89*	27.67*
Overall	434.6±51.23	138.95±5.59	186.19±12.67
%Adequacy	101	214	31
TIA, n=49			
Winter	78.02±5.67	105.14±5.12	136.44±9.04
%Adequacy	18	162	22
Summer	340.5±11.85	151.36±3.01	147.51±8.35
%Adequacy	79	233	25
F-Ratio	392.6*	60.13*	0.81[NS]
Overall	209.3±14.81	128.25±3.78	141.98±6.19
%Adequacy	49	197	23
Recommendations/ Tolerable limits	430●	65♣	600♣
F-Ratio (SIA Vs TIA)	47.24*	9.34*	10.89*

♣ WHO (1989) ● WHO (1972)
* Significant at 5% level NS= Non-significant

areas. In earlier study , Ahuja, (1997) reported a higher intake of nickel by men in same sewage irrigated area (400 µg/ day) as compared to 140 µg /day in tube well irrigated area.

The data in Table 2 revealed that intake of manganese was 2-3 times the suggested value of ICMR (2000) in both areas and in both seasons. However, average intake of iron in sewage irrigated area was nearly 86% of ICMR's recommended values while it comprised 149% of the requirement in tube well irrigated area. Average intake of Mn in women from tube well irrigated area was significantly higher than that in women from sewage irrigated area. However, iron values in the subjects from two areas were almost similar. Setia et al. (1998) reported higher values for iron while Grewal and Hira (1995) and Mann et al. (1997) reported lower iron intake by adult Indians. High intake of iron in the subjects from the sewage irrigated area was primarily due to the high iron contents in seasonal vegetables compared to those subjects inhabiting the tube well irrigated areas. Manganese content of wheat, rice and green leaves in tube well irrigated area was higher than that in sewage irrigated area. Sharma (1981) observed that the leafy vegetables like spinach and fenugreek leaves had accumulated greater amount of heavy metals as compared to other crops. Since the vegetative growth was maximum in leafy vegetables and roots proliferation was also proportional to shoot growth so it leads to higher uptake of metals along with the other nutrients.

Table 2: Average daily intake of Mn, Fe, Cu, Zn and Ca (mg/day) by women of sewage and tube well irrigated area around Ludhiana city (Punjab).

Area	*Mn*	*Fe*	*Cu*	*Zn*	*Ca*
SIA, n=23					
Winter	8.98	24.94	12.04	13.39	684.30
	±0.74	±1.39	±0.71	±0.79	±33.48
%Adequacy	164	83	545	84	171
Summer	11.41	26.68	13.8	14.77	687.2
	±0.98	±1.65	±0.73	±0.84	±25.93
%Adequacy	207	89	627	95	172
F-Ratio	20.48*	45.49*	32.23*	112.31*	0.92^{NS}
Overall	10.2	25.81	12.92	14.08	685.72
	±0.67	±1.12	±0.55	±0.60	±22.39
% Adequacy	185	86	587	91	172
TIA, n=49					
Winter	11.99	25.04	11.27	13.05	1484.94
	±0.36	±1.42	±0.45	±0.37	±55.58
% Adequacy	218	83	500	84	371
Summer	13.92	64.21	11.08	15.79	1106.5
	±0.20	±33.67	±0.19	±0.60	±24.0
% Adequacy	253	214	504	109	277
F-Ratio	21.30*	1.32^{NS}	0.15^{NS}	14.79*	38.29*
Overall	12.59	44.63	11.18	14.42	1295
	±0.23	±16.98	±0.25	±0.38	±35.8
%Adequacy	229	149	508	93	324
Recommendations/ Tolerable limits	5.5♠	30.0♠	2.2♠	15.5♠	400♠
F-Ratio (SIA Vs TIA)	17.66*	0.35^{NS}	37.85*	0.61^{NS}	1912.4*

♠ WHO (1989) ● WHO (1972)

* Significant at 5% level NS= Non-significant

Average intake of copper was 5-6 times the suggested value of ICMR in both the areas, however women in sewage irrigated area had significantly higher intake . It corroborates the findings of Ahuja (1997). Intake of zinc in both the areas was nearly equal to ICMR's suggested value of 15.5 mg/day and area-wise differences were non-significant. Intake of zinc was significantly higher during summer in both the areas. Zinc content of foods in two areas did not vary much and therefore its intake also did not differ. Setia (1994) reported that the Zn intake by adult population belonging to tube well and sewage irrigated area was 15.2-21.0 mg/ day and 19.3-40.6 mg/day, respectively which was higher than the present study.

Intake of calcium by adult women in both areas was 1.8 to 3.0 times of the ICMR's recommended allowances, but the intake was significantly higher by women in tube well irrigated areas. Though calcium content of drinking water in sewage irrigated area (1.73 mg/ 100g), was more than that in tube well irrigated area (0.61 mg/100g) but calcium content of wheat flour in tube well irrigated area was significantly higher than that from sewage irrigated area. Intake of calcium was comparable to the earlier reports for population in Punjab (Grewal and Hira, 1995 and Hira et al., 1993).

CONCLUSION

It is concluded that mineral intake by any population is more a reflection of the type of soil and water of the area rather than the amount of foods consumed by the individuals. Environmental factors contribute significantly to the mineral content of the foods and therefore, mineral intake by the population in the area also gets influenced accordingly . Compared to earlier studies (Ahuja, 1997 and Setia et al., 1998) from this institute in this area, a reduction in consumption of toxic heavy metals like lead, cadmium and nickel have been observed but further action need to be taken to ensure safe food and water supply for better health and work output of the population.

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