ABSTRACT

Sapota (Manilkara achras Mill. Fosberg) is an important fruit crop of India. Umbergaon and Dahanu Taluka are amongst the main growers of Sapota in India. The present study was an attempt to investigate Nickel content in soils of orchards, in irrigation water and in sapota fruits from Dahanu (Maharashtra State, India) and Umbergaon (Gujrat State, India) talukas. The chronic daily intakes of Nickel through these sources were calculated and were compared with international reference standards.

Key Words: Nickel, Soil, Water, Sapota, Chronic daily intake values

INTRODUCTION

Sapota (Manilkara achras Mill. Fosberg) is a tropical fruit that originated in Mexico. It is cultivated in tropical countries like Jamaica, Sri Lanka, India, Malaysia, Philippines and parts of USA like Florida. It was introduced to India from Singapore more than hundred years ago. Sapota is an important commercial crop in Dahanu Taluka (Maharashtra State, India) and Umbergaon Taluka (Gujrat State, India). Dahanu Taluka has more than 7000 hectares of land under sapota cultivation. A monthly turnover of around Rs. 3 – 4 crore results from sale of nearly 12,500 tons of sapota from Dahanu Taluka. Dahanu has a thermal power station and Umbergaon taluka has a number of industrial units. As a result of these activities, various heavy metals may be released into the lithosphere. In the primary investigation, arsenic, cadmium, cobalt, lead, mercury and nickel contents soil, water and sapota fruit samples in the areas of investigation were measured. Other heavy metals except nickel had negligible or non-detectable (less than 0.5 parts per billion) values. Nickel contents and chronic daily intakes of nickel through these sources are studied, calculated and compared with international reference standards.

MATERIAL AND METHODS

Industrial townships of Vapi, Sarigam and Umbergaon in Umbergaon Taluka (Gujrat State, India) are chosen for their sapota cultivation and proximity to industries. Dahanu, Dahanu Taluka (Maharashtra State, India) is chosen for its sapota cultivation and proximity to a thermal power plant. Bordi, another important sapota growing village in Dahanu Taluka is also included in area of survey. Bordi, in comparison with other four places of survey is neither close to any industry nor to any power plant.

Soil analysis

Soil samples were collected as per standard protocols. Care was taken to avoid taking samples from area too close to an irrigation channel, too close to a fertilizer application etc.

Water analysis

The aim was to find out nickel content of irrigation water. To determine this, water samples were taken from the borewells in the orchards and not from any polluted waste water source. To take the
sample, water was pumped out from the borewell. Water obtained in the first 5 minutes was discarded and then the samples were collected, labeled and subjected to analysis.

Nickel analysis
Nickel analysis was done as per APHA standard methods\(^5\). AA 100 - Atomic Absorption Spectrophotometer (Perkin Elmer, USA) was used to detect nickel content of the samples of soil, water and sapota fruits at parts per million (ppm) level. The samples that yielded notable readings with AA 100 were subjected to further analysis using AA 400 - AAS graphite (Perkin Elmer, USA) to detect Nickel at parts per billion (ppb) level.

RESULTS AND DISCUSSION
Nickel contents of Soil, water and Sapota samples from various places under investigation were as per Table 1.

Nickel content of soil
Significant amount of nickel was present in all the soil samples. Vapi soil had the highest nickel concentration (13920.5 ppb). Nickel in soil may enter human system by actual ingestion of soil directly or indirectly. Leece and Rifat\(^6\) point out that the problems are compounded since nickel can be bio-accumulated in the food chain. Nickel affects immune system. Exposure to nickel may result in eczema and dermatitis. Metallic nickel and nickel sulphate are carcinogenic. US EPA (1995)\(^7\) has calculated Oral Reference Dose-RfD of nickel for non-carcinogenic effect as 20 µg/kg/day. Considering various safety factors and uncertainty factors, No Observable Adverse Effects Level (NOAEL) of nickel is calculated as 5 mg/kg/day\(^7\). Considering direct or indirect intake of soil to be 80 mg and 20 mg respectively for children and adults\(^6\), Chronic Daily Intake (CDI) for nickel from soil samples is calculated (Table 2). Average weights of children and adults are assumed to be 15 kg and 70 kg, respectively. Average life expectancy is considered as 70 years\(^6\). Calculations are carried out with following formula\(^6\). All these daily intake values are far below the critical values of RfD\(^7\) (20 µg/kg/day) and NOAEL\(^7\) (5 mg/kg/day).

Water analysis
Dahanu sample had the highest nickel content (3.660 ppb). Dahanu soil sample had one of the second highest nickel readings (12917.2 ppb, second in rank after Vapi soil sample). Correspondingly, Dahanu water sample had the highest nickel value (3.66 ppb). Soil-borne nickel may enter ground water by percolation. In accordance with literature reference, leaching of nickel from soil to water was very low, even negligible\(^6\). Nickel levels of soil samples in the range of 8000-14000 ppb were translated to mere 0-4 ppb nickel in water samples. These values are much less than the Indian Standards\(^8,9\) of 0.02 ppm (20 ppb). Nickel levels of all the five water samples were also lower than the Environmental Protection Agency drinking water standards\(^10\) as

\[
\text{CDI (µg/kg/day)} = \frac{\text{Intake of Ni (child) x 7 years}} {15 \text{ kg} \times 70 \text{ years}} + \frac{\text{Intake of Ni (adult) x 63 years}} {70 \text{ kg} \times 70 \text{ years}}
\]

<table>
<thead>
<tr>
<th>Value in parts per billion</th>
<th>Bordi</th>
<th>Sarigam</th>
<th>Vapi</th>
<th>Umbargaon</th>
<th>Dahanu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>8591.60</td>
<td>10835.80</td>
<td>13920.50</td>
<td>12141.20</td>
<td>12917.22</td>
</tr>
<tr>
<td>Water</td>
<td>2.667</td>
<td>2.764</td>
<td>3.131</td>
<td>3.427</td>
<td>3.660</td>
</tr>
<tr>
<td>Fruit</td>
<td>43.31</td>
<td>124.46</td>
<td>330.37</td>
<td>146.21</td>
<td>418.54</td>
</tr>
</tbody>
</table>

Table 1: Nickel contents of soil, water and sapota at various places

<table>
<thead>
<tr>
<th>Ni CDI (µg/kg/day)</th>
<th>Bordi</th>
<th>Sarigam</th>
<th>Vapi</th>
<th>Umbargaon</th>
<th>Dahanu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0068</td>
<td>0.0086</td>
<td>0.0110</td>
<td>0.0096</td>
<td>0.0102</td>
</tr>
</tbody>
</table>

Table 2: Chronic Daily Intake (CDI) for nickel from soil
0.1 ppm (100 ppb). Environmental Protection Agency\(^\text{10}\) (EPA, USA) had studied different implications of nickel on health in detail. EPA did not find nickel to potentially cause health effects from acute exposures at levels above the Maximum Contaminant Level (MCL). The Agency, however, admits that nickel has the potential to cause the following health effects from long-term exposures at levels above the Maximum Contaminant Level decreased body weight; heart and liver damage; dermatitis. Assuming 600 ml and 2 litre of daily water consumption by children and adults, respectively\(^6\), consumption of nickel per day by children, by adults and average chronic daily intake (as per above mentioned formula\(^6\)) through drinking water is as per Table 3. All these readings are fairly small and negligible.

**Fruit analysis**

All sapota samples had significant amount of nickel content in them. Dahanu sapota had the highest nickel content (418.54 ppb). Nickel was absorbed to a higher extent by the fruits. It should be noted that, Fruit Products’ Order (FPO) (1955)\(^11\) does not mention maximum permissible limit for Nickel. Recommended dietary intake of fruits for children and adults is 50g and 30g respectively\(^12\). With the same assumptions,

<table>
<thead>
<tr>
<th>Ni CDI (µg/kg/day)</th>
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<th>Sarigam</th>
<th>Vapi</th>
<th>Umbargaon</th>
<th>Dahanu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>0.1067</td>
<td>0.1106</td>
<td>0.1252</td>
<td>0.1371</td>
<td>0.1464</td>
</tr>
<tr>
<td>Adult</td>
<td>0.0762</td>
<td>0.0790</td>
<td>0.0895</td>
<td>0.0979</td>
<td>0.1046</td>
</tr>
<tr>
<td>Average(^6)</td>
<td>0.0792</td>
<td>0.0821</td>
<td>0.0930</td>
<td>0.1018</td>
<td>0.1088</td>
</tr>
</tbody>
</table>

the Chronic Daily Intake of Nickel through food will be as per Table 4.

Assuming that all the foods grown in the local area have similar Nickel content as that observed in the sapota fruits, and as per 800 g and 1100 g daily food intake by children and adults, respectively\(^12\), the Chronic Daily Intake of nickel through food will be as per Table 4.

Values of nickel intake obtained considering contribution from fruits alone are very low- almost negligible. Assumption that all the food consumed also has similar nickel content gives us significantly higher intake values. Lower nickel content of fruit sample of Bordi is reflected in lower values of nickel consumption either by fruits alone or by all food. Summing up of all the values of nickel consumption (Table 2 to Table 4), total daily intake values are as per Table 5.

All these combined daily intake values are far below the critical values of RfD\(^7\) (20 µg/kg/day) and NOAEL\(^7\) (5 mg/kg/day).

**CONCLUSION**

The samples of soil and water from the places under investigation do have significant
Table 5: Total Chronic Daily Intake (CDI) for Nickel from soil, water and food

<table>
<thead>
<tr>
<th>µg/kg/day</th>
<th>Bordi</th>
<th>Sarigam</th>
<th>Vapi</th>
<th>Umbargaon</th>
<th>Dahanu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>0.0068</td>
<td>0.0086</td>
<td>0.0110</td>
<td>0.0096</td>
<td>0.0102</td>
</tr>
<tr>
<td>Water</td>
<td>0.0792</td>
<td>0.0821</td>
<td>0.0930</td>
<td>0.1018</td>
<td>0.1088</td>
</tr>
<tr>
<td>Food</td>
<td>0.8435</td>
<td>2.4240</td>
<td>6.4343</td>
<td>2.8476</td>
<td>8.1516</td>
</tr>
<tr>
<td>Total</td>
<td>0.9296</td>
<td>2.5147</td>
<td>6.5384</td>
<td>2.9590</td>
<td>8.2705</td>
</tr>
</tbody>
</table>

quantities of heavy metals in them. Though the levels are not in the extreme range, they are alarming enough. Nickel content of the fruits is almost negligible. The sum total of nickel consumption through soil, water and food is at present far below than RfD and NOAEL values. Presence of nickel in soil and water is a matter of concern. Presence of heavy metals in sapota should be monitored and attempts must be made to minimize the same in view of rules and regulations of export market and Indian domestic standards. In view of the nickel content of sapota, it may be worthwhile to find out content of nickel and other heavy metals in other food sources. This may lead to a better judgment of overall chronic daily intake of nickel, other heavy metals and repercussions thereof.

REFERENCES


