Role of fluoride and its enhancement by aluminium for the chronic kidney disease in the NCP, Sri Lanka

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What is this problem of Chronic renal failure (CRF)?

In Sri Lanka the North central province with a 6% population of the national population is facing CRF at an unprecedented proportion where the incidence of CRF has risen to 20% of all cases detected in the country. Prevalence in the affected areas is around 15%.
<table>
<thead>
<tr>
<th>Water source</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dug well</td>
<td>69.3</td>
</tr>
<tr>
<td>Tube well</td>
<td>18.1</td>
</tr>
<tr>
<td>Tap water</td>
<td>3.2</td>
</tr>
<tr>
<td>Others</td>
<td>9.5</td>
</tr>
</tbody>
</table>
Ground water Fluoride distribution in Padaviya area
Some chance observations

• People exclusively use locally fabricated sub-standard aluminum utensils for cooking

• These develop holes through them after sometime

• Holes are soldered with a lead based solder
Previous studies linking aluminium and fluoride to kidney failure

- Al and F levels of 0.5 ppm (Aluminium) and 1 ppm (Fluoride) given to rats caused the death of animals after 45 weeks with only few deaths in the control group.
- Brain aluminium levels were much higher in rats given Al+F.
- Pathological changes in the kidneys with aluminium containing deposits located in blood vessels of the kidney.
- **Rats died due to kidney failure**
Chemical analysis of a sample Aluminium pot

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>1.17</td>
</tr>
<tr>
<td>Lead</td>
<td>0.82</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.52</td>
</tr>
<tr>
<td>Ni</td>
<td>0.06</td>
</tr>
<tr>
<td>Traces of Sb, As, Cr and Tl</td>
<td></td>
</tr>
</tbody>
</table>
Dissolution of the utensils
Welded Aluminium pot using Pb
Raw materials
Working hypothesis

• Both aluminium and fluoride are essential factors in causing Chronic renal failure
• Fluoride enhances leaching of aluminium from cooking utensils
• In the presence of acidic components of food this combined effect is further enhanced
Al leaching in deionised water

![Graph showing the relationship between fluoride concentration (ppm) and Al leached (ppm).](image)
Al leaching in tamarind media

![Graph showing the relationship between fluoride concentration (ppm) and aluminium leached (ppm).]
Al-F equilibria

1. $\text{Al}^{3+} + \text{F}^- \rightarrow \text{AlF}^{2+}$  \hspace{1cm} K_1 = 10^{7.8}$
2. $\text{AlF}^{2+} + \text{F}^- \rightarrow \text{AlF}_2^+$  \hspace{1cm} K_2 = 10^{4.9}$
3. $\text{AlF}_2^+ + \text{F}^- \rightarrow \text{AlF}_3^-$  \hspace{1cm} K_3 = 10^{4.1}$
4. $\text{AlF}_3^- + \text{F}^- \rightarrow \text{AlF}_4^{2-}$  \hspace{1cm} K_4 = 10^{2.6}$
5. $\text{AlF}_4^{2-} + \text{F}^- \rightarrow \text{AlF}_5^{2-}$  \hspace{1cm} K_5 = 10^{1.2}$
6. $\text{AlF}_5^{2-} + \text{F}^- \rightarrow \text{AlF}_6^{3-}$  \hspace{1cm} K_5 = 10^{0.2}$
<table>
<thead>
<tr>
<th>Sample Name</th>
<th>F Conc. in ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.1</td>
<td>0.10</td>
</tr>
<tr>
<td>S.2</td>
<td>0.12</td>
</tr>
<tr>
<td>S.3</td>
<td>0.16</td>
</tr>
<tr>
<td>S.4</td>
<td>0.00</td>
</tr>
<tr>
<td>S.5</td>
<td>0.08</td>
</tr>
<tr>
<td>S.6</td>
<td>0.14</td>
</tr>
<tr>
<td>S.7</td>
<td>0.12</td>
</tr>
<tr>
<td>S.8</td>
<td>0.18</td>
</tr>
<tr>
<td>S.9</td>
<td>0.16</td>
</tr>
<tr>
<td>S.10</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Fluoride analysis in Serum

![Fluoride analysis in serum graph](attachment:image.png)
Important clinical finding

• All renal failure patients at the Kandy nephrological unit suffer from dental and skeletal fluorosis
Studies from other countries

- Andrapradesh (Nalgonda district) has high fluoride content in drinking water often reaching over 7 ppm.
- A similar kidney disease has been reported from this district very similar to our CRF not attributed to hypertension or diabetes.
Arsenic and cadmium?

• WHO report does not explain why this disease is prevalent only in certain areas since all other areas use the same agrochemicals.

• It has exorbitantly high urine arsenic levels of 45 ppm while no other group in Sri Lanka found such values!

• No. of samples too small to make general conclusions.

• Urinary excretion of heavy metals is compromised at such high GFR values (< 50)

• No arsenic poisoning symptoms in any of the CKD cases
Arsenic and cadmium in Sri Lanka

- Wet zone and dry zone have the same arsenic levels
- There is no arsenic in rice.
- Arsenic in sea fish is about 3000 μg/kg
- Arsenic in air is about 1 ppb
Conclusions

- There is a positive correlation between high fluoride in water and kidney disease.
- Aluminum may act as a carrier to transport fluoride through the blood-brain barrier and other biological membranes.
- Observation of skeletal fluorosis confirms our theory.
- Importance of the fluoride filter assumes added significance.