Centre for Science and Environment's Study on

Environmental contamination and its association with CKDue in North Central region of Sri Lanka

Anuradhapura, August 16, 2012

About CSE

- One of India's leading non-profit public interest research institutions
- Set up in 1980 to promote environmentally sound and socially relevant development paradigm
- With more than 150 people, CSE works on a wide array of environment and development issues including water and waste management, industrial pollution & regulations, environmental health, climate change, renewable energy, air pollution and mobility management etc.

About CSE

- Publish India's leading science and environment fortnightly: *Down To Earth*
- Set up Anil Agarwal Environment Training Institute as a leading training institute in South Asia
- Work with government and non-governmental partners in South Asia to promote and support sustainable development

About Pollution Monitoring Laboratory (PML)

- The Pollution Monitoring Laboratory was set up in 2000 to monitor environment pollution and food contamination
- Was setup as an independent lab to support communities and to investigate **issues** of public health concern
- Has state of the art equipments (GC-MS, HPLC, AAS etc.) to monitor trace organics and metals, criteria air and water pollutants and other food and environmental samples.

Key Study and Impacts

- Feb 2001: Endosulfan study in Kasaragod, Kerala
  - 2001: Kerala government suspended the use of endosulfan in the state
  - May, 2011: Supreme Court of India banned the production, sale, exports and use of endosulfan across the country
- Feb 2003: Analysis of pesticide residues in bottled water
  - July 2003: Govt. notifies norms for pesticide residues in bottled water

Key Study and Impacts

- August 2003 & 2006: Analysis of pesticide residues in carbonated beverages
  - August 2003, The fourth Joint Parliamentary Committee (JPC) was set up to investigate the CSE study
  - Based on JPC recommendations, new food law was enacted replacing the old one and the entire food safety governance structure was changed; the pesticide rules were changed too
  - August 2008: Union Health Ministry notified rules for maximum levels of pesticides in carbonated water; the first in the world

Key Study and Impacts

- June 2005: Analysis of blood samples of farmers in the cotton belt of Punjab – *cancer registry established*
- 2008: Monitoring of pesticides in the environmental samples of Nepal – *first study ever undertaken*
- Feb 2009: Fatty acid profile of edible oil and fats in India – *setting-up of transfats standards*
- August 2009: Analysis of lead content in paints – *companies voluntarily agreed to remove lead*
- Sept 2010: Analysis of antibiotic residues in honey – *advisory issued and standards notified*

Sri Lanka Study – CKDue

- In 2011: Hon'ble Minister for water supply and drainage Mr Dinesh Gunawardana requested CSE to assist in water quality testing to understand the cause of renal failure in North Central region
- Centre for Environmental Justice (CEJ), Colombo also approached CSE for a study to probe the probable causes for Chronic Kidney Disease of unknown etiology [CKDue] in North Central region
- CSE did the study in association with CEJ

CKDue Background

- CKDue has emerged as a major public health concern in the North Central Region of Sri Lanka
- Hypertension and Diabetes, the most common factors for Chronic Kidney disease, are not responsible for kidney failures in these regions
- Diagnosis is usually in the final stages; mortality rate is very high in the affected population
- Mostly among male agricultural workers between age group of 30-60 years; women and children too getting affected

CKDue Background

- Incidence were first reported from North Central Province (NCP)- Anuradhapura and Polonnaruwa are the worst affected
- Cases of CKDue now reported from adjoining provinces as well

CKDue-Theories

- ***Cadmium (Cd)*:** Linked CKDue to Cd exposure through the food chain. Fertilizer identified as the major source of Cd contamination. However, studies done later contradicted the findings. Also, does not explains the absence of disease in other regions using similar fertilizers.
- ***Fluoride in drinking water:*** Linked CKDue to high fluoride levels in drinking water sources. However, a 2010 study showed high fluoride levels both in CKDue affected and non-affected.

CKDue-Theories

- ***Combination of Fluoride in drinking water and aluminum pots:*** A 2009 study linked people affected by CKDue with consumption of fluoride rich water and almost exclusive use of sub-standard aluminum pots for cooking and storing water. The study postulated that Aluminofluoride complexes may play a significant role in causing chronic renal failure. However, this theory does not explain the geographical prevalence of CKDue.

CKDue-Theories

- ***Arsenic:*** The theory of arsenic as the main causative factor of CKDue has come to the fore in recent years. And agrochemicals are suspected to be the major source of Arsenic. The studies show that the post mortem test of the diseased kidney have deposition of Calcium Arsenate crystals. The theory links formation of Calcium arsenate with the reaction of arsenic in agrochemicals with calcium in hard water. The entry of calcium arsenate is mainly through drinking water.

CKDue-Theories

- ***Other probable reasons:***
  - Hardness in drinking water
  - *Cyanobacterial toxin*
  - *Illicit liquor*
  - Use of herbal/ayurvedic medicines
  - Pesticides and bioaccumulation
  - **Multi-factorial**

Methodology

- Literature review
- Meeting government agencies, doctors and researchers in Sri Lanka
- Based on the above, decided on sampling area – affected as well as control area
- With the help of CEJ and local doctors identified affected people in the communities; recorded their medical history and life style parameters and then collected samples
- Samples were properly preserved and transported to India for testing at PML

CSE's Objective

- In Sri Lanka, the quality of drinking water is at the base of most theories linked with CKDue.
- In many studies, trace metals (especially arsenic) in the environment have been identified as a major geo-environmental factor contributing to CKDue.
- ***The focus of the study was to analyze drinking water quality for physico-chemical parameters and heavy metals in affected and unaffected regions.***
- ***Samples of soil, food commodities (rice grain and plant), pesticides and fertilizers were also tested for arsenic to understand the linkage of arsenic with CKDue.***

Sri Lanka Study - Samples

- CSE & CEJ team visited the north central region of Sri Lanka in February 2012
- 40 water samples were collected (35 from endemic region; 5 from control) -- *Dug well, tube well, municipal supply, tank and spring water samples*
- Soil (16), rice (6), fertilizers (3) and pesticides (5) samples

Sri Lanka Study - Samples

- Samples collected from the following endemic areas in the North Central Region: Dehiattakandiya (Ampara district), Girandurukotte and Mahiyanganaya (Badulla district), Hingurukgoda and Medirigiriya (Polonnaruwa district) and Padaviya, Medawachchiya and Kabithigollawa (Anuradhapura district)
- Control samples were collected from Kandy district

Sri Lanka Study

- ***District-wise samples***
  - Ampara (Eastern Province): 10 water samples (6 well, 1 tube well, 2 tank, 1 municipal supply), 4 soil samples and 1 rice plant sample
  - Badulla (Uva Province): 5 water samples (4 well, 1 municipal supply), 2 soil samples and 1 rice plant sample
  - Polonnaruwa (North Central Province): 10 water samples (8 well, 2 tube well, 1 tank), 4 soil samples, 1 rice plant sample and 2 rice grain sample
  - Anuradhapura (North Central Province): 10 water samples (6 well, 1 tube well, 1 tank, 2 spring), 4 soil samples and 1 rice plant sample
  - Kandy (Central Province): 5 water samples (1 tube well, 2 Municipal supply, 1 spring, 1 river) and 2 soil samples

Sri Lanka Study-Water Analysis

- All the physico-chemicals parameters in water samples tested
    - pH, hardness, TDS, calcium, magnesium, sulfate, chloride and fluoride
    - Standard methodology provided by American Public Health Association (APHA 1985) was used
    - Results compared with SLS 614: 1983 (Sri Lanka standards for potable water)

Sri Lanka Study-Water Analysis

- Heavy metals tested
  - Lead, cadmium and chromium analyzed
  - EPA method 3010 A by Flame Atomic Absorption Spectrometry (FLAA)
  - Detection limit for lead was 0.01 ppm, cadmium 0.01 ppm, and chromium 0.02 ppm
  - *Arsenic* in water samples was analyzed using standard methodology prescribed by Environment Protection Agency, EPA method 7060A –Graphite Furnace Atomic Absorption Spectrometry (GFAA). Detection limit for arsenic was 0.002 ppm.

Sri Lanka Study-Water Analysis

- **Total Dissolved Solids (TDS)**
  - Maximum Desirable Levels: 500 mg/l
  - Maximum Permissible Levels: 2000 mg/l

- TDS detected in all the 5 districts were within the maximum permissible levels of 2000 mg/L (as per SLS 614:1983)
- Average concentration of TDS were as follows:
  - Kandy: 113.2 mg/l (range: 50.1- 367 mg/l)
  - Ampara: 187 mg/l (range: 32.5- 599 mg/l)
  - Badulla: 217.7 mg/l (range: 85- 399 mg/l)
  - Polonnaruwa: 341.3 mg/l (range: 112- 486 mg/l)
  - Anuradhapura: 399.3 mg/l (range: 56.4 - 792 mg/l)

Sri Lanka Study-Water Analysis

- **Hardness**
  - Maximum Desirable Levels of 250 mg/l
  - Maximum Permissible Level of 600 mg/l
  - Study shows that hardness was within maximum permissible limits though it was higher in the endemic districts
  - Average hardness was as follows:
    - 136 mg/l in the Kandy district
    - 154 mg/l in Badulla district
    - 210 mg/l in Ampara district
    - 256.7 mg/l in Polonnaruwa district
    - 274.1mg/l in Anuradhapura district

Sri Lanka Study- Water Analysis

- **Calcium**
  - Maximum Desirable Levels of 100 mg/l
  - Maximum Permissible Levels of 240 mg/l
  - Calcium content is well within the maximum permissible limit; though the maximum levels found in Polonnaruwa and Anuradhapura are 50-70% higher than the maximum desirable levels
    - Kandy- 43.2 mg/l (range 12-100 mg/l)
    - Ampara- 53.6 mg/l (range 8-120 mg/l)
    - Badulla - 69.6 mg/l (range 52-80 mg/l)
    - Polonnaruwa- 69.3 mg/l (range 40 -140 mg/l)
    - Anuradhapura- 84.4 mg/l (range 8.0-172 mg/l)

Sri Lanka Study-Water Analysis

- **Fluoride**
  - Maximum Desirable Level is 0.6 mg/l
  - Maximum Permissible Level is 1.5 mg/l
  - WHO recommends 0.5 mg/l for tropical countries
  - CSE study shows that fluoride levels were within the maximum permissible levels except for one sample in Polonnaruwa district
    - Kandy: 0.5 mg/l (range 0.3 to 0.9 mg/l)
    - Ampara: 0.6mg/l (range 0.4-1.2 mg/l)
    - Badulla: 0.9 mg/l (range 0.6-1.2 mg/l)
    - Anuradhapura: 0.9 mg/l (range 0.4 -1.5 mg/l)
    - Polonnaruwa: 0.9 mg/l (range 0.5-1.7mg/l)

Sri Lanka Study-Water Analysis

- **Other Parameters**
  - Chloride, sulfate and magnesium were within the desirable limits in both affected and unaffected areas.
- **Heavy Metals**
  - **Cadmium, Arsenic, Chromium and Lead were not detected in drinking water samples collected from affected or unaffected regions**

Arsenic in other samples

- **Arsenic:**
  - Soil (16), rice (6), fertilizers (3) and pesticides (5) were tested
  - The agrochemical samples were analyzed using standard methodology prescribed by Environment Protection Agency, EPA method 7060 – Graphite Furnace Atomic Absorption Spectrometry (GFAA)
  - The soil samples were tested using standards prescribed by Environment Protection Agency, EPA method 7062–Vapour Hydride Generation (VGA) by Borohydride generation method
  - The rice samples were analyzed by Vapour Hydride Generation (VGA) using Borohydride generation method
  - LOD: Soil- 0.004 ppm; Rice- 0.06 ppm; Pesticides and Fertilizers-0.004 ppm

Arsenic in other samples

- Arsenic was detected in 16 soil samples in the range of ND-0.28 ppm
- The mean arsenic level in the soil sample from the affected region was 0.06 ppm and from the control region it was 0.035 ppm
- The levels of arsenic found in the soil samples are well within the PERMISSIBLE LEVELS prescribed by the US Agency for Toxic Substances and Disease Registry (7.2 ppm) and the European Community (20.0 ppm) for agricultural soil.

Arsenic in other samples

- Rice is most susceptible to arsenic accumulation compared to other cereals. However, **Arsenic was not detected in rice grain or rice plant samples from the affected areas**
- Arsenic was detected in the range of 0.009 to 0.254 ppm in 5 most commonly used pesticides—insecticide, weedicide and fungicide. The levels detected are very low and suggest that arsenic is likely to be present as an impurity from other ingredients rather than adulteration of these products. **Sri Lanka had banned Arsenic in Pesticides in 2001.**

Arsenic in other samples

- Arsenic was detected in the range of 0.09 to 0.406 ppm in fertilizer samples – Urea 0.203 ppm, TSP 0.406 ppm and MOP 0.090 ppm. The levels detected are very low and suggest that arsenic is likely to be present as an impurity from other ingredients rather than adulteration of these products.
- The samples of pesticides and fertilizer were randomly selected and the sample size is small. A larger study on the agrochemicals needs to be done conclusively establish the levels of arsenic in them.

Conclusions

Water samples

- **Total Dissolved Solids** exceeded the maximum desirable levels of 500 ppm in 6 out of 40 samples—5 dug well water and 1 tube well water, all in the affected areas.
- **Hardness** exceeded the maximum desirable levels of 250 ppm in 14 out of 40 samples—11 dug well water and 3 tube well water. 1 tube well water sample, which exceeded the maximum desirable levels, was from the control area.

Conclusions

Water samples

- **Calcium** exceeded the maximum desirable levels of 100 ppm in 9 out of 40 samples—7 dug well water and 2 tube well water, all from the affected areas.
- **Alkalinity** exceeded the maximum desirable levels of 200 ppm in the 5 out of 40 samples—4 dug well water and 1 tube well water, all from the affected areas.

Conclusions

Water samples

- **Fluoride** levels exceeded the maximum desirable levels of 0.6 ppm in 22 out of 40 samples—15 dug well water, 5 tube well water, 1 municipal supply and 1 tank water sample.
- 1 tube well sample, which exceeded the maximum desirable levels, was from the control area.
- One tube well sample from Polonnaruwa exceeded the maximum permissible levels of 1.5 ppm.

Conclusions

Water samples

- **People in the affected areas are drinking relatively poor quality water (mostly groundwater) with high levels of hardness, calcium, TDS and fluoride than those in the unaffected areas**

Conclusions

Water samples

- Heavy metals—*lead, cadmium, chromium and arsenic*—were not detected in drinking water samples collected from the affected and control areas.
- **Heavy metals in drinking water is not related to CKDue in the North Central region of Sri Lanka. If heavy metal is responsible, then there is a different source for it than drinking water and that source should be explored**

Conclusions

Other samples

- Arsenic levels in soil samples are well within permissible limits established by the US and the EC
- **Arsenic levels in agrochemicals are impurity levels, but more investigation is required to establish this.**

Recommendations

- Efforts should be made to supply clean drinking water to villages so that their dependence on unfiltered groundwater is eliminated.
- Medical facilities in the affected area should be upgraded.
- Government should increase the number of mobile clinics so that patients can be diagnosed at an early stage and treatment can begin.
- Dialysis is critical. Enough dialysis sets should be made available in the district hospitals to ensure that patients do not have to travel far for their treatment.

Recommendations

- Government of Sri Lanka should support further research on CKDue and its linkages with environmental and life style patterns.
- It should also organize an annual symposium/ meeting and bring all the experts working on the issue of CKDue together to forge a way ahead.