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Current status of Chronic Kidney Disease of unknown etiology in Sri Lanka: causative factors and possible links

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Rajarata is the rice bawl of Sri Lanka for over two millennia and during the last two decades, noteworthy numbers of patients with Chronic Kidney Disease of unknown etiology (CKDu) were reported from Rajarata area of Sri Lanka. This has been identified in the 1990s, to be endemic to certain geographical areas of Sri Lanka, including Medawachchiya, Padaviya, Kebithigolawa, Medirigiriya, Hingurakgoda (North Central Province), Nikawewa (North Western Province), Dehiattakandiya (Eastern Province) and Giradurukotte (Uva Province). It is reported that approximately 99 % of CKDu patients are farmers and source of drinking water of CKDu patients are obtained from dug wells (92 %) and tube wells (08 %). Ages of majority of the CKDu patients are between 30 – 40 years and they are heavily exposed to agrochemicals as very little attention is given to hazardous effects on human health.

In the past, several researchers have attempted to explain the etiology of CKDu. Herath et al. (2005) reported that medium to high fluoride content in drinking water caused the CKDu, Bandara et al. (2008) reported that presence of high concentrations of cadmium in drinking water and food as a potential cause of CKDu. Chandrajith et al. (2010) have shown that no such high Cd levels were detected in drinking water and food from the CKDu endemic areas. Later in 2010, it was reported that presence of toxins produced by cynobacteria in surface waters was the reason for this disease however the results could not bring out a plausible explanation for CKDu to be prevalent only among those who drink groundwater. As such, none of the previous work on the subject could adequately explain the etiology of CKDu. Jayasumana, et al., (2011) have reported that significantly higher percentage

of CKDu patients showed spotty pigmentations on their soles and palms, high concentrations of arsenic in urine and hair samples collected from CKDu patients. Analysis of organ samples of deceased CKDu patients from the study area also have shown about ten-fold increase of arsenic in comparison to that of kidneys of an unexposed individual. This study was further strengthen by the research findings reported by Jayatilake et al. (2013) from WHO research group as their results revealed that presence of arsenic and cadmium in urine, hair and nail of subjects in the study area and contamination of food with arsenic and cadmium.

The inhabitants in CKDu prevailing areas complained that they observe a significant increase in the hardness of well water over the last two decades. Extents of hardness in groundwater resources of Sri Lanka appear to have a strong positive correlation with the distribution of prevalence of CKDu patients in Sri Lanka. Hardness of water from CKDu prevalence area including 'Gonameriyawa' water spring at Kebithigollewa, a place where no CKDu patients are reported were analyzed. The results revealed that water hardness from CKDu prevalence area were ranged from 300 – 850 mg L^{-1} and Gonameriyawa water spring in Kebithigollewa showed 6.2 ± 0.7 - 9.2±2 mg L^{-1}. Hardness of water from canals and reservoirs were below 220±5.3 mg L^{-1}. Levels of arsenic and cadmium in water used by CKDu were range from 1.1 µg L^{-1} - 12.3 µg L^{-1} and 0.14 µg L^{-1} – 5.54 µg L^{-1}. The regression analysis of water hardness versus CKDu patients indicated 67.6 % relationship and 82.2 % correlation between two variables was observed. One of the strong evident to indicate the hardness of water is a causative factor for the prevalence of CKDu, is the inhabitants who consume water from Gonamariyawa spring in Kebithigollawa area are not affected from CKDu ($p<0.05$). Arsenic contents in soil profiles, rice, selected aquatic and terrestrial plants were analyzed in the study areas with a view to understanding the vertical and horizontal (spatial) distribution of arsenic in the environment. The results revealed that all surface soil samples contained total arsenic contents greater than those in the bottom horizons of the soil profiles. Surface layers of soil in paddy fields of Padaviya area were detected to have relatively high levels of arsenic (1.5 mg kg^{-1}) when compared to that of the deep layers (0.61 mg kg-1). No arsenic was detected below 7 feet depth in Padaviya reservoir. Andrew, et al., (2013) reported that the rice

samples were collected from different parts of the country and amounts of arsenic and cadmium in those rice samples were range from 3.6 μg kg^{-1} - 183 μg kg^{-1} and 0.5 μg kg^{-1} - 800 μg kg^{-1} respectively. Analysis of plant species in the endemic area showed that most of the plant species analyzed contained the greater amount of As. In order to investigate the source of arsenic in the environment, agrochemicals available in the retailed market of CKDu prevalence area was analyzed. The highest arsenic content was observed in phosphate containing chemical fertilizers used in rice cultivation. The total arsenic content in TSP ranged from 25.49 mg kg^{-1} to 37.86 mg kg^{-1}. Moderate amount of arsenic, ranged from 6.02 mg kg^{-1} to 7.61 mg kg^{-1} was present in the dolomite samples when compared to the phosphate containing fertilizer. The pesticides used in endemic area was tested for As and the results have confirmed the presence of As in the range of 180±14 μg kg^{-1}-2586±58 μg kg^{-1} and the amount of arsenic present was varied depending on the type of active ingredient, brand and batch of pesticides. The results of the present study revealed that presence of arsenic in the soils and plants, particularly in the agricultural areas gradually decreases with depth, indicating that it is not present naturally in the bedrocks nevertheless has been introduced from the surface, most probably due to anthropogenic activities such as agrochemicals.

Although several research groups were conducting research to explore the etiology of the CKDu during last two decades, the research group from University of Kelaniya and University of Rajarata was invented the effect of arsenic on CKDu for the first time. Hence the study was conducted to find out the source of arsenic in CKDu patients. The results revealed that agrochemicals are the major sources of trace toxic elements in CKDu patients and it was indicated that chronic exposure of people in the endemic area to low levels of arsenic and cadmium through food chain. Sufficient evidence is therefore available to show the effect that wide use of contaminated phosphate fertilizer and pesticides could be the major sources of arsenic and cadmium contamination in the largest rice growing areas of Sri Lanka.

It is recommended therefore that the Secretariat of fertilizer, Department of Agriculture, Ministry of Health in Sri Lanka and other regulatory authorities

which are responsible for implementation of regulations for control of toxic elements in agrochemicals, may collectively share the responsibility of developing pragmatic strategies to control entry of arsenic / cadmium to the country through imported agrochemicals, especially inorganic phosphate fertilizer through effective monitoring and control measures mediated through appropriate legal and institutional infrastructure. In order to reduce the use of agrochemicals, educational programme should be conducted to promote environmental friendly farming methods and to enhance the public awareness on impacts of hazardous agrochemicals and their use.