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Evidences of Heavy Metal Contamination & Their Consequences in Sri Lanka with Special Reference to Agriculture: A Review

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ABSTRACT

The health and Environmental implications associated with accumulations and contamination of Heavy metals is of great concern, particularly in agricultural production systems. However, both essential and toxic elements were absorbed by vegetables & edible fishes from the soil and water. Although there are several reasons for heavy metals contamination of soil and irrigation water Intensification of agriculture is a major reason for accumulation of heavy metals due to excess use of agrochemicals and amendments in all over the Sri Lanka. Since there are only limited data for Heavy Metal accumulation and Contamination Need further studies on their consequences of health and environmental impact in Sri Lanka. Protecting the agricultural soil is a formidable challenge in Sri Lanka, which requires modernization of Technology using in Sri Lanka on agro chemical, fertilizers and irrigation systems thereby improving the recovery of soil and recycling of wastewater. The evidence of elevated heavy metal accumulation and contamination in leafy vegetables, soils & irrigation water in Sri Lanka emphasizing the importance of extensive monitoring and investigations of heavy metal accumulation in soil, water and edible food to reduce the health risk and environmental pollution.

Keywords: *RMLs - recommended maximum limits, Mts - Metric tons, GLV -Green Leafy vegetables, CKDu – chronic Kidney Disease, NIV - Newly Improved Varieties*

INTRODUCTION

Increasing Intensification of agriculture could have resulted in accumulation of heavy metals due to excess use of agrochemicals and amendments. Heavy metals concentration may accumulate to toxic level which can cause a risk to human health [Reena Singh *et al., 2011*]. Continuous discharge of industrial and residential waste water into the lagoon is a potential source of environmental pollution. Many of the sediments in our rivers, lakes and oceans have been contaminated by pollutants [Paul *et al., 2012*, Fides Simon*et al., 2016*]. Pollutants are directly discharged by industrial plants and municipal sewage treatment plants, others come from polluted runoff in urban and agricultural areas and some are the results of historical contamination [Aksoy *et al., 2005*, Desta Woldetsadik*et al., 2017*]. Contaminated sediments can be threatening creatures in the benthic environment, exposing worms, crustaceans and insects to hazardous concentrations of toxic chemicals. Some polluted sediment can kill benthic organisms, thereby reducing the food available to larger animals such as fish [Awofolu,O*et al., 2005*, Pan, Y*et al., 1997*]. Heavy metals such as copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) are considered to be useful micro-nutrients to plants [R. A. Aziz*et al., 2015*]. When these metals exceed maximum acceptable limits they become toxic to the plants [Satpathy D *et al 2014*].

Other type of heavy metals is cadmium (Cd), arsenic (As) and chromium (Cr) will be more toxic to plants than the others and have no any reported biological functions to plants [Ji,W *et al.*, 2012]. The heavy metal concentrations in normal irrigation water and soils would be below than the recommended maximum limits (RMLs). Moreover, Cd, Co, Cr, Cu, Ni and Zn concentrations in vegetables were lower than the RML (recommended maximum limits) standards [Desta Woldetsadik*et al., 2017*]. Heavy metal contamination in vegetables, water & sediment is a major concern in determining

food safety, quality and understanding adverse health impacts [Jaffa, M*et al., 1998*, Long XX*et al., 2002*].

Effects of Elevated Levels of Heavy Metals Associated With Agricultural Activities in Sri Lanka

Heavy Metals Contamination in Agriculture Soil & Irrigation Water in Sri Lanka

As soil is an important constituent of the human biosphere, any harmful change to this segment of the environment seriously affects the overall quality of human life [Syed *et al., 2012*]. There are several sources of heavy metals contamination in agricultural soil. But heavy metal accumulation was increasing day by day Due to Intensification of agriculture by excess use of agrochemicals and amendments in all over the Sri Lanka. The previous study done in Ethiopia says that The heavy metal concentrations in regular irrigation water and soils did not exceed the recommended maximum limits (RMLs) in Agriculture field and Cd, Co, Cr, Cu, Ni and Zn concentrations in all analyzed edible vegetables were lower than the RML standards [Desta Woldetsadik *et al., 2017*]. Moreover, The Sri Lankan study says that the geo-enrichment for many elements indicates slight to significant variations between agricultural and non-agricultural soils in Sri Lanka [Jayawardana DT *et al., 2014*].

Triple super phosphate widely were using in Sri Lanka which contain permissible levels of heavy metals recommended by the Sri Lankan Standard Institute. In Sri Lanka, application of phosphate fertilizers, pesticides, fungicides and organic manures were higher than the agrochemical doses recommended by the Department of Agriculture, had been a common practice among the farmers for many years. Therefore, long-term application of agrochemicals may be responsible for heavy metal accumulation in soil in Sri Lanka [Lakmalie HMP *et al., 2010*].

Heavy metal concentrations show variations among different land used areas while metal pollution in the area increases in the order of residential < industrial < commercial area. When compared with the other parts of the world, Colombo Metropolitan Region is less polluted with respect to Zn and Pb. However, Cu pollution is high. Zinc (Zn), Cu and Pb may have released from common sources [Herath HMDV *et al., 2014*]. There is a another statement that Seasonal rainfall, dilution and other run-off during the wet season, metals from the upper layer of soil were flushed out to some extent and hence all the indices values were lower in Wet season compared to the dry season in Sri Lanka [Syed *et al., 2012*]. Hence, the seasonal variation is also contributing in heavy metal contamination in Sri Lanka. Agricultural soil contamination with heavy metals through the repeated use of agrochemical, While Residential soil contaminated with heavy metal due to rainfall & flooding of untreated wastewater from agriculture area in Sri Lanka.

The most adverse effect of heavy metals is that they can be introduced into the food chain from soil & environment and threaten human health. Agricultural products cultivating on soils with high metal concentrations are represented by metal accumulations at levels harmful to human and animal health as well as to the bio-environment [Paul B Tchounwou *et al., 2012*,Syed*et al., 2012*]. But, there are no sufficient dates of heavy metal contamination in soil to study about the consequences of heavy metal contamination of soil in Sri Lanka. Determining the extent of heavy metals contamination in agricultural soils is emphasizing the importance of extensive monitoring & investigations of heavy metal in Sri Lanka. Hence, Regulations should be introduced on agrochemical applications to protect soil resources from further contamination in Sri Lanka [Premarathna HMPL*et al., 2010*].

Heavy Metals Accumulation in Green Vegetable &Rice

Green leafy vegetables are considered as a good source of nutrients (vitamins, minerals, fibers and phytochemicals), particularly among urban populations dependent on plant based diets. The crops are able to increasethe trace element concentrations in green leafy vegetables.The heavy metals included Ni, Cd, Cr and Pb levels exceeded the maximum permissible limits set by FAO/WHO for human consumption. Long term consumption of heavy metal contaminated GLV (Green Leafy vegetables) may possibly cause numerous health hazards in human. This is explaining as bio accumulation of heavy metals was transferred trough food Chains. Therefore, regular monitoring of heavy metals in GLV is crucial to avoid excessive buildup of these metals in the human food chain [Sharma RK*et al.,* 2009,Thilini Kananke*et al.,* 2014]. The

pattern of metal contamination depending on the cultivation sites because the Environmental parameters also contributed in heavy metal contamination. This statement clearly explained by Nirmali *at al* on 2016, their study was on measurement of the contamination of heavy metals (Zn, Cu, Ni, Pb, Cd, Mn, Cr, Hg and As) in three aquatic vegetables. Their results showed that all vegetables exceeded the permissible levels in the concentrations of Pb, and Cr. Both Water spinach and Lasia roots showed Cd ranging from 1.01 – 2.77mg/kg and0.84 -9.23 mg/kg respectively.Both Samples exceeding permissible levels of heavy metals and the metal ion concentrations did not vary with the sites of collection for water spinach and Lasia root. However, the Mn and Cr concentrations in the Lotus roots were different depending on the site of collection [Nirmali Wickramaratne*et al*., 2016, Rathnayake RMPS, 2005]. In Addition,The different food processing methods is also suitable to reduction of heavy metal from green vegetables. In Sri Lanka , The average concentrations of metals detected in raw, cooked and stir-fried green leafy vegetable such as ["Mukunuwenna" (Altemanthera sessilis), 'Thampala" (Amaranthus viridis), "Nivithi" (Basella alba), “Kohila Leaves" (Lasia spinosa) and "Kankun" (Ipomoea aquatica)]. The results showed no significant differences in heavy metal contents among three processing methods [Kananke TC *et al*., 2015].The average concentrations of Ni, Cd, Cr and Pb in the field and market Mukunuwenna(Alternanthera sessilis) samples have exceeded the recommended values in Sri Lanka. Long term consumption of contaminated Mukunuwenna may cause detrimental effect on human and animals [Thilini Kananke*et al*., 2015] The Cd to Zn ratio in soils indicated safer limits for Cd in more than 95% of the soils studied. Metals in soils correlated significantly with number of years cultivated. Sri Lankan leafy vegetables and soils have elevated heavy metal concentrationsand their sources.It is associated with health effects to human and the ecosystem at large due to food chain transfer of toxic heavy metals [Yadav SK*et al*., 2010]. Sri Lanka is a nation with high per capita consumption of rice [Channa Jayasumana*et al*., 2015]. Crops such as rice that are grown in submerged conditions are even more exposed to heavy metal sources both from the soil and water. Rice being the second most consumed crop in the world may in turn expose the majority of its consumers to the heavy metals [Emumejaye K , 2014].A high proportion of arsenic in rice exists in the inorganic form. Rice cultivated in Sri Lanka is contaminated with arsenic. There is no difference between the arsenic content in (Newly Improved Varieties) NIV rice samples from areas where there is high or low prevalence of CKD [Channa Jayasumana*et al*., 2015].

Whereas food crops may be exposed to heavy metal through contaminated soil or atmospheric dispersal of such metals from industrial areas, human beings may be exposed to heavy metals through consumption of contaminated foods such as rice [Chronopoulos J*et al*., 1997, Machiwa JF, 2010].The rice plants exposed to higher levels of Cd showed growth inhibition in plant height, chlorophyll content in flag leaf, leaf area, number of tillers and root dry weight. Addition of external Cd as cadmium chloride, highest amount of Cd always accumulated in traditional rice varieties within all plant parts (i.e rice grains, shoots and roots) than new improved rice varieties in Sri Lanka. Therefore, the traditional rice varieties can accumulate a considerable amount of Cd within their body than new improved rice varieties with normal soil conditions in Sri Lanka [Herath MDAK*et al*., 2014].

All previous study indicates that the importance of extensive investigations of Sri Lankan leafy vegetables and soils since there are no sufficient data had been published. This review study is going to encouragethe researches to study on Heavy metal contamination & accumulation.

EVIDENCES FOR HEALTH &ENVIRONMENTAL IMPLICATIONS OF HEAVY METALS ACCUMULATION IN SRI LANKA

Heavy Metals Contamination in Agricultural Soil Extent of contamination in soil science perspective, heavy metals contamination in agricultural soil refers to the presence of heavy metals of significant toxicity. There are limited data of heavy metal contamination in agricultural soils in Sri Lanka. Heavy metals contamination in the environment may cause detrimental effects to both plants and animals including human being. Heavy metals are non-degradable and stay longer in the soil [Zhao K *et al*., 2015]. There is a connection between heavy metals and water. Because heavy metals are part of Earth's crust, they can be worn away by the action of weather. When they are worn off of

rock, they can collect in surface or groundwater [Mohiuddin KM *et al*., 2011]. Depending on the chemistry of the water, the metals might stay in the water, or come out of the water and gather on an available surface of plants. However, fishes are relatively situated at the top of the aquatic food chain; therefore, they normally can accumulate heavy metals from food, water and sediments. Heavy metals can, therefore, enter peoples' bodies via drinking water and food [Yilmaz F *et al*., 2007, Samanthika R*et al*., 2016 and Zhao S *et al*., 2012]. Previous studies say that metal bioaccumulation by fish and subsequent distribution in organs is greatly inter-specific. In addition, many factors can influence metal uptake like sex, age, size, reproductive cycle, swimming patterns, feeding behavior and living environment [Mustafa C *et al*., 2003].

The heavy metal cadmium (Cd) is known to be a widespread environmental contaminant than other kind of heavy metals such As , Cr and Ni and a potential toxin that may adversely affect human health, especially kidneys as the target organ. Agriculture & Farming is the major source of income for the villagers of North-central Sri Lanka. However, chronic kidney disease of unknown etiology is a major health hazard in Sri Lanka and it is assumed that agricultural contaminants are the major causative agents [Jayawardana DT *et al*., 2014]. Because of Prior to the Green Revolution, the amount of fertilizer used in rice cultivation in 1970 was 32,000 metric tons (Mts) rising to 74,000 Mts in 1975. Up to 68.9 Mts of Cd could have entered into the rice-cascade reservoir environment from triple superphosphate (TSP) use since 1973 in Sri Lanka. Diversion of the Mahaweli River in 1970–1980 further increased cadmium input. Cadmium transferred from Upper Mahaweli water to Polgolla in Sri Lanka. Cadmium content of the sediments from reservoirs collecting cadmium from irrigated TSP fertilized crop fields (rice and vegetables) [Bandara, JMRS*et al*., 2008, 2010 and Zhao K*et al*., 2010].Arsenic (As) and Cadmium (Cd) are two of the heavy metals that gained public and national attention of the Sri Lankan community. Globally, As and Cd are reported as two of the most toxic heavy metals that cause physiological and biochemical alterations and mortality in exposed organisms. Cadmium levels in the range of 0.001 to 0.138 mg l-1 have been reported in both ground and surface water sources of Sri Lanka. Few studies in the country have documented levels of arsenic in natural water bodies. Furthermore, studies assessing the potential toxicity of these two metals to species that are of importance to Sri Lanka, are scarce.

Potential of heavy metal accumulation in edible fish such *Mystus Gulio* in Sri lanka emphasize the importance of monitoring heavy metal accumulation in water and edible food Specially in fish [Senarathne P *et al*., 2007].However, fish are relatively situated at the top of the aquatic food chain; therefore, they normally can accumulate heavy metals from food, water and sediments. The effects of environmentally relevant levels of As and Cd on the commercially exploited fresh water prawn Macrobrachium rosenbergii, in Sri Lanka. The heavy metals induced significantly higher levels of mortality of prawn in series of concentrations of either As (from 0.001 to 0.08 mg l-1) and Cd (from 0.001 to 0.05 mg l-1) [Ranatunge RAAR *et al*., 2013].Therefore, many international monitoring programs have been established in order to assess the quality of fish for human consumption and to monitor the health of the aquatic ecosystem [Meche A *et al*., 2010].

The possible source of Cd in reservoir sediments and water is contaminated by agrochemicals. The CRF (Chronic renal failure) prevalent in north central Sri Lanka is a result of chronic dietary intake of Cd, supported by high natural levels of fluoride in drinking water, coupled with neglecting of routine de-silting of reservoirs for the past 20 years [Senevirathna DMAN *et al*., 2008].The previous studies said that the causative factor for CKD is probably environmental and is related to the nature of anthropogenic activities. Hence, CKD were evaluated with established chemical, geochemical, and health risk of As, Cd and Pb in Sri Lanka. As a result, it can be justified that CKD of the North Central Province (NCP) in Sri Lanka is a decease caused by the chronic exposure and cumulative effects of elevated levels of heavy metals associated with agricultural activities [Sunethra Kanthi Gunatilake*et al*., 2014]. Some of the early studies on Chronic Kidney Diseases in the dry zone regions of Sri Lanka have attributed the prevalence of the disease to the high level of Cd in geo-environmental media [Chandrajith, R*et al*., 2011].

Heavy metals excessively present in the urine samples of patients with Sri Lankan Agricultural Nephropathy (SAN) are capable of causing

damage to kidneys. Synergistic effects of multiple heavy metals and agrochemicals may be nephrotoxic. [Channa Jayasumana*et al*., 2015]. The mean cadmium level in surface water in the dry zone of Sri Lanka is 0.0003 mg/L, which is very much less than the World Health Organization permissible limits. The average Cd content in rice samples are 0.011 mg/kg dry weight while there is no significant difference between the Cd contents in rice grains from both affected and non affected regions. The mean Cd level found in lotus rhizomes in the dry zone is 7.47 mg/kg varying from 6.79 to 8.57 mg/kg. These results indicate that the affected regions do not contain high levels of cadmium. The Cd contents in water and rice from the affected regions were much lower indicating that Cd is not a contributing factor to the CKD with uncertain etiology in Sri Lanka [Rohana Chandrajith*et al*., 2012 and Singh RP*et al*., 2010]. The prediction of effect of heavy metals accumulation and contamination in Sri Lanka is very challenging for the reviewers due to lack of data.

CONCLUSION

The Soil, water, leafy vegetables and rice contains Cd heavy metal and Cd is not contributing factor to the CKD with uncertain etiology in Sri Lanka. Regular monitoring of heavy metals in leafy vegetables and Edible Fishes should be performed to ensure the consumer safety. There are Significant differences in heavy metal contents in different food processing methods. So the different food processing methods also suitable to reduction of heavy metal from green vegetables.

The initial evidence of elevated heavy metal concentrations in Sri Lankan Saied leafy vegetables and soils &Potential of heavy metal accumulation in edible fish in Sri Lanka emphasizing the importance of extensive monitoring & investigations of heavy metal accumulation in water and edible food. Since there are only limited data for Heavy Metal Contamination & their consequences in Sri Lanka needs extensiveinvestigations on Heavy Metal accumulation, Contamination in food chain as well as Environment and their consequences in Sri Lanka.

The impact of anthropogenic heavy metal contamination on agriculture soil and crops in Sri Lanka will be use full to reduce the health risks that newly raised previous ten years.

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