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දුරකථන) 0112669192 , 0112675011
தொலைபேசி) 0112698507 , 0112694033
Telephone) 0112675449 , 0112675280

ෆැක්ස්) 0112693866
பெக்ஸ்) 0112693869
Fax)0112692913

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மின்னஞ்சல் முகவரி) postmaster@health.gov.lk
e-mail)

වෙබ් අඩවිය) www.health.gov.lk
இணையத்தளம்)
website)

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Ministry of Health

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Secretary
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80/5,
"Govijana Mandiraya"
Rajamalwatta Lane,
Battaramulla

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Add.Sec (AT)
25/Oct/2021

Re: Health impact of chemical fertilizer and pesticide use

This is with reference to your letter dated 04-06-201 No. MA/Sec/01/15 Vol I on the same subject.

The report prepared by the Ministry of Health on the above subject is attached for your information and necessary action.

Dr. S. H. Munasinghe
Secretary
Ministry of Health

Dr. S. H. Munasinghe
Secretary
Ministry of Health
"Suwasiripaya"
385, Rev. Baddegama Wimalawansa Thero Mawatha,
Colombo 10. Sri Lanka.

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385, Rev. Baddegama Wimalawansa Thero Mawatha, Colombo 10, Sri Lanka.

Health effects of chemical fertilizers and pesticides

Agrochemicals are chemical fertilizers and pesticides. Herbicides, insecticides and fungicides are the major categories of pesticides. Urea, phosphate and potash are the main groups of chemical fertilizers used in Sri Lanka (Ekanayake 2009). Chemical fertilizers contain trace amounts of heavy metals and metalloids (Chandrajith et al. 2009). Continuous application of contaminated fertilizers during the past fifty years (since green revolution) may have contributed to increase heavy metals and metalloids in the soil and groundwater aquifers (Weggler et al. 2004).

Starting in the mid-1960s, successive governments and the agricultural department have encouraged (by introduction of heavy subsidies) Sri Lankan farmers to use chemical fertilisers and pesticides. (Krauss et al., 2011). This has led to excessive usage of fertilizers and increased yield of crop that in turn has led to food security. For an optimum production of agriculture; the application of chemical fertilizers and pesticides has become necessary but also this has a major impact on the environment and human health. Mainly the misuse of them has resulted in many environmental, occupational and health problems.

A large amount of chemicals is annually applied to soil as fertilizers and pesticides. Such applications may result in the increase level of heavy metals, particularly Cadmium (Cd), Lead (Pb), and Arsenic (As) in the soil (Atafar et al. 2010). Sri Lankan scientists reported that paddy soil in Mahaweli development areas (most of the CKDu endemic areas) are polluted with potentially toxic metals, and paddy soil in Sri Lanka are highly modified by artificial fertilizer applications (Perera et al, 2021). 226 samples of Fertilizers and 273 samples of pesticides collected from four areas in the north central province, Padaviya, Medawachchiya, Mahawilachchiya and Anuradhapura indicated that almost all the agrochemicals available to the farmers in the study area are contaminated with arsenic (Jayasumana et al, 2015).

A comprehensive analysis of published data indicates that heavy metals such as As, Cd, chromium (Cr), Pb, and mercury (Hg) present naturally. However, anthropogenic activities contribute significantly to environmental contamination. These metals are systemic toxicants known to induce adverse health effects in humans, including cardiovascular diseases, developmental abnormalities, neurologic and neurobehavioral disorders, diabetes, hearing loss, hematologic and immunologic disorders, and various types of cancer. Human co-exposure to cadmium and inorganic arsenic resulted in a more pronounced renal damage than exposure to each of the elements alone (Tchounwou et al, 2012). Both lead and methylmercury show significant trans placental transfer (Hutton, 1987).

Health effects due to heavy metals

(Hutton, 1987; Tchounwou et al, 2012; WHO, 2011)

Heavy metal	**Source**	**Remark**	**Health effects**
Arsenic	insecticides, herbicides, fungicides, algicides, sheep dips, wood preservatives, dye-stuffs	arsenic does accumulate in hair, skin and nails	Affects virtually all organ systems • Skin: Hyperpigmentation, Hyperkeratosis Skin tumours • Liver: Liver dysfunction Haemangioendothelioma • Cardiovascular system: Peripheral vascular disturbances leading to gangrene • Nervous system: Peripheral neuropathy, Paresthesia in hands and feet, Hearing defects • Haematopoietic system: Disturbed erythropoiesis with anaemia, Peripheral vascular disease, Gangrene of feet • Reproductive system: Increased frequency of spontaneous abortions • Cancer (skin, kidney, bladder) • The role of arsenic in lung cancer is equivocal.
Cadmium	employment in primary metal industries, eating contaminated food, smoking cigarettes, working in cadmium-contaminated work places	accumulated in the kidney and liver, particularly in the renal cortex.	• 'itai-itai disease' (characterized by severe renal dysfunction and damage to bone structure) • Respiratory: - Chronic obstructive lung disease (COPD), Lung fibrosis (restrictive), Lung cancer • Renal: - Proximal tubular necrosis, Proteinuria, secretion of beta 2 microglobulin (renal dysfunction) • Skeletal: - Osteomalacia & osteoporosis, Bone pain (Itai-Itai) • Cardiovascular: hypertension • Cancer: lungs, kidney, prostate and stomach Other: anosmia

Lead	fossil fuels burning, mining, and manufacturing Lead has many different industrial, agricultural and domestic applications.	the greatest percentage of lead is taken into the kidney, followed by the liver and the other soft tissues such as heart and brain, however, the lead in the skeleton represents the major body fraction (90%).	Affects several organs in the body including the kidneys, liver, central nervous system, hematopoetic system, endocrine system, and reproductive system • Haematological system: reduced haem synthesis and anaemia (At higher levels of exposure) • Nervous system: (the most vulnerable target of lead poisoning): Headache, poor attention spam, irritability, loss of memory and dullness CNS impairment at moderate exposure in children. reflected by inattention, cognitive difficulties, fine motor dysfunction and altered EEG patterns. Under heavy exposure, encephalopathy may arise. • Renal system: Long-term heavy exposure may result in irreversible nephropathy
Mercury	accidents, environmental pollution, food contamination, dental care, preventive medical practices, coal industry and other industrial and agricultural operations, occupational operations	methylmercury displays considerable affinity for the brain	• Gastrointestinal toxicity, neurotoxicity and nephrotoxicity • Methylmercury intoxication is characterized by effects on the CNS and the areas mainly affected are those associated with the sensory, visual and auditory functions and those concerned with co-ordination • Dementia

Health effects due to direct exposure of chemical fertilizers and pesticides

Effects of direct exposure to pesticides ranged from headaches, dizziness, nausea to blurred vision. (Wilson, 1998). Organophosphate pesticides have increased in application, because they are both less persistent and harmful for environment than organochlorin pesticides. But, they are associated with acute health problems, such as abdominal pain, dizziness, headaches, nausea, vomiting, as well as skin and eye problem (Sharma & Singhvi, 2017). Farm employees have exceptional risks linked with skin contact intoxication and inhalation throughout handling and/or treatment of pesticides to crops (Hassaan & Nemr, 2020).

Health effects suspected to be due to a chemical fertilizers and pesticides

A field study carried out in Sri Lanka showed numerous health costs and environmental pollution has been revealed in terms of long term and short term due to the direct exposure to these chemicals for the farmers as well as to the consumers. The health effects are from both nitrogenous fertilizers and pesticides (Wilson, 2000).

Fertilizers used in agriculture are a major source of water contamination, especially shallow aquifers (Tivy, 1990) in rural areas. The degradation of pesticide runoff in water has two major impacts on human health. The first is the ingesting of shellfish and fish that are contaminated by pesticides. The second is the direct ingesting of water contaminated with pesticide (Hassaan & Nemr, 2020). Many diseases, including cancers have been linked to nitrates in drinking water. Nitrogenous fertilizer has been identified as one of the causes of methaemoglobinaemia, commonly referred to as the Blue-Baby syndrome in agricultural areas (Pretty and Conway, 1988). Organophosphate pesticides used in the vegetables gradually get deposit into human body and has a link with cancer (Miah et al. 2014). Prolonged exposure to pesticides could also lead to cardiopulmonary disorders, neurological and hematological symptoms and skin diseases (Rola & Pingali, 1993).

Chronic kidney disease of unknown origin (CKDu) and chemical fertilizers and pesticides use

Some studies have shown that exposure to chemical fertilizers and pesticides could be one of the risk factors of chronic kidney disease of unknown origin. But some other studies indicated that it is unlikely that long-term low-level exposure to agrochemicals has an impact on the development of CKDu. The aetiology of CKDu is probably multifactorial and no cause effect relationship is established up to now.

Community survey carried out among 6153 study participants in three spatially distinct regions of Sri Lanka, namely, Medawachchiya (NCP, 2003),Yatinuwara (CP, 2005) and Hambantota (Southern Province, 2008) indicated that farming is a risk factor for kidney disease in Medawachchiya. Farming, together with exposure to agrochemicals and family history of CKD were identified as risk factors in Hambanthota. But in Yatinuwara, diabetes and long-standing hypertension were the identified risk factors (Athuraliya et al 2011). Another cross-sectional study conducted in Anuradhapura, Polonnaruwa and Badulla showed a significant dose–effect relationship between urine cadmium concentration and CKDu stage ($P < 0.05$). Urine cadmium and arsenic concentrations in individuals with CKDu were at levels known to cause kidney damage. These results indicate chronic exposure of people in the endemic area to low levels of cadmium through the food chain and also to pesticides. Significantly higher urinary excretion of cadmium in individuals with CKDu, and the dose–effect relationship between urine cadmium concentration and CKDu stages suggest that cadmium exposure could be a risk factor for the pathogenesis of CKDu (Jayathilake et al, 2013).

A review conducted by Wanigasuriya in 2012, using fifteen manuscripts published in peer-reviewed scientific journals and two peer reviewed abstracts indicated that CKDu mainly affects males from poor socio-economic backgrounds who are involved in paddy farming. Significant predictors of kidney disease in these patients included age, history of smoking, being under treatment for hypertension and drinking well water in the fields. Studies on heavy metal and ochratoxin exposure have revealed conflicting results. Fluoride content of well water in all these areas exceeded the WHO recommended level of 0.6 mg/L. Water in all areas was alkaline which could facilitate mobilization of fluoride from minerals indicating a fluoride mediated mechanism for renal damage. In conclusion, aetiology of CKDu in NCP of Sri Lanka is probably multi-factorial involving one or more environmental factors and a possible genetic predisposition in vulnerable populations (Wanigasuriya, 2012).

A descriptive cross-sectional study was carried out by Peiris-John et al to determine whether there was an association between chronic renal failure (CRF) and low-level organophosphate pesticide exposure. This study was conducted at the renal clinics of the Anuradhapura Teaching Hospital (exposed patients) and National Hospital of Sri Lanka (non exposed patients) and Moratuwa fishing village (non-exposed controls) and Uda Walawe irrigation scheme (exposed controls). This study was unable to conclude an aetiological association between CRF and low-level organophosphate pesticide exposure (Peiris-John, 2006).

In a case controlled study, 183 chronic renal failure patients of unknown aetiology attending the renal clinic at Teaching Hospital Anuradhapura were compared with a control group from the general medical clinic of the same hospital. significant predictors of chronic renal failure of unknown aetiology included family history of chronic renal dysfunction, a history of having taken ayurvedic treatment and having had a snake bite in the past. The use of pesticides was excluded in the multivariate model. Hence it is unlikely that long-term low-level exposure to pesticides has an impact on the development of chronic renal failure (Wanigasuriya, 2007)

Drinking water in the rural areas is obtained mainly from wells while reservoirs are the main source of irrigation for paddy lands in the NCP of Sri Lanka. Bandara et al have found high levels of Cd, iron (Fe) and Pb in five reservoirs in the high CKDu prevalent areas. Cd content in lotus rhizomes and fish was reported as high. The Provisional Tolerable Weekly intake of Cd, based on the extreme exposure by rice and fish, was also found to be high in the region. They attributed the high cadmium levels to the heavy use of Cd contaminated fertilizer in the region. These observations have led to the hypothesis that cadmium, a well-known nephrotoxin could be a likely aetiological agent of the CKDu (Bandara et al., 2008).

However, above findings were later challenged by Chandrajith et al. They collected drinking water and rice samples from endemic and non-endemic regions, and urine samples from patients, asymptomatic relatives and healthy control urine samples from a non-endemic region. Samples were analyzed for trace and ultra-trace elements including heavy metals Cd and uranium (Ur). The fluoride content in water samples was measured. The results indicated that drinking water from both endemic and nonendemic regions contained moderate to high levels of fluoride. The Cd content in drinking water and rice from endemic regions and urine from patients and healthy people was much lower indicating that Cd is unlikely to be a contributing factor for CKDu in Sri Lanka (Chandrajith et al., 2011).

196 paddy samples collected from Padaviya Divisional Secretariat area (the second highest prevalence of CKDu in Sri Lanka) were analysed for heavy metals and mercury was not detected in any of the rice samples and 21 (11%) had no detectable levels of lead or cadmium. Seventeen (9%) samples contained cadmium exceeding 50 µg/kg and lead exceeding 100 µg/kg. Tolerable daily intake of cadmium is 50 µg/kg (Jayalal, 2020).

In another study conducted by the same author in 2019, an assessment was carried out to quantify chronic exposure to cadmium, lead and arsenic through food in people living in Medawachchiya where prevalence of CKDu is highest. Assuming the major route of intake is food, and based on the quantity and type of food items consumed, a 60 kg man is exposed to average doses of 83.7 µg cadmium, 924.1 µg lead, and 180.3 µg arsenic per week. The impact of chronic lead exposure was affirmed by a mean blood lead level of 3.0

µg/dL, with a maximum level of 8. 8 µg/dL being observed in some cases. Chronic low dose exposure of lead from food appears to be a public health concern in the studied population. Cadmium exposure through food appears to be of concern also. However, arsenic exposure through food appears to be within safe limits (Jayalal, 2019). One of the reasons for food to have these heavy metals could be agrochemical use in food production.

CKDu is a major public health issue with high mortality in the Pacific coastal regions of Central America. A cross-sectional survey conducted to determine the risk factors for this disease showed that agricultural labor was associated with CKDu (OR = 2.48, 95%CI: 1.59, 3.89, $p < 0.0001$), but there was no association with agricultural non field work (OR = 0.91, 95%CI: 0.60, 1.38, $p = 0.65$) (Sanoff, 2010).

El Salvador has the highest overall mortality from kidney disease in the world, and CKD is the second leading cause of mortality among men of working age in the country. In a research involving participants from a sugar cane company in Nicaragua and a group of more than 2000 sick ex-workers and their families indicated that none of the established risk factors for CKD appear to play an important role in the epidemic. Similarly, there is no evidence of high exposure to nephrotoxic metals such as lead or cadmium. On the other hand, while there are a number of environmental, occupational and behavioral factors to which the affected population is potentially highly exposed and that can cause injury to the kidney under certain circumstances, they are not known to cause CKD or certainly not on such a large scale. These factors include heat and strenuous labor combining to cause chronic volume depletion, arsenic, agrichemicals, leptospirosis and medications such as non-steroidal anti-inflammatory drugs, analgesics or aminoglycoside antibiotics (Ramirez-Rubio, 2013).

As requested, here we are submitting a report on health effects of chemical fertilizers and pesticides. Health effects of organic fertilizers are not discussed in this report.

Recommendations

- Correct misuse: proper training to the farmers regarding correct use
- Close monitoring of pesticides sale, quality control and post-harvest use
- Non promotion of chemical fertilizers and no subsidies for chemical fertilizers
- Subsidize organic fertilizer
- Balanced approach with organic fertilizer and chemical fertilizer
- Monitor chemicals in drinking water
- Take measures to ensure food security.

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