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# Characteristics of Rice Growing Soils under Conventional and Organic Input Systems in Sri Lanka

**M.G.T.S. Amarasekara, K.S. Waduge and A.M.K.R. Bandara**

Faculty of Agriculture, Rajarata University of Sri Lanka, Puliyankulama, Anuradhapura, Sri Lanka.

## Abstract

The conventional rice farming in Sri Lanka heavily depends on chemical inputs. There is a growing trend to move towards organic rice farming which is considered healthier and more sustainable. However, some studies revealed that in practice this is not always true. This study was conducted to compare soil characteristics between organic and conventional rice input systems in Sri Lanka under irrigated condition. Soil samples were collected from rice fields located in Rice Research and Development Institute at *Bathalagoda* and two farmer fields at *Rambawa* and *Eppawala* where both organic and conventional systems are practiced in same location. All three locations have more than 05 years of farming history with totally organic inputs. Soil samples drawn from 0-15 and 15-30 cm depths of organic and conventional rice fields were analyzed for different soil characteristics. Two factor factorial model was used in statistical analysis. Organic fields showed significantly higher ($p<0.05$) soil pH, organic matter, and cation exchange capacity (CEC) while available N, P and soil EC were significantly higher ($p<0.05$) in conventional fields. Arsenic and Cd reported in both fields were comparable and remarkably low. Two organic fields showed significantly higher ($p<0.05$) microbial C contents indicating improved soil health condition. The result of the study concludes that increased soil organic matter content in organically managed rice fields enhances soil fertility by improving organic C, CEC and microbial population of the soil.

***Keywords:*** Conventional agriculture, Organic farming, Rice farming in Sri Lanka, Soil hemical properties

## 1. Introduction

Conventional farming is heavily dependent on use of synthetic fertilizers and agro chemicals. However, many studies have revealed that intensive farming with high chemical inputs is not economically and ecologically sustainable. In Sri Lankan context, overuse of agrochemicals and fertilizers has become a common but serious environmental issue. Triple super phosphate fertilizer imported for paddy farming in Sri Lanka contain arsenic, cadimium and lead as impurities (Bandara *et al*., 2010). These hazardous elements which have been reported as impurities of pesticides and fertilizers are well known nephrotoxins and possible contributing factors for chronic kidney disease (CKD) prevails in the dry zone Sri Lanka (Jayasumana *et al*., 2015 a). Rice farming is the most common agricultural practice in CKD affected region and possible heavy metal sources such as fertilizer are applied in abundance in the rice fields (Chandrajith *et al*, 2010). Many studies have reported that heavy metals in those inputs could accumulate in soils and become readily available to plant uptake (Sanjeewani *et al.*, 2012 and Chandrajith *et al*., 2010). Glyphosate was a widely used herbicide in Sri Lanka which has strong metal-chelating properties by complexation with hardness of water by forming nephrotoxic metallic compounds. In addition, importation of fertilizer and other agro chemicals lead to draining of the country's foreign exchange. Organic farming has been identified as an alternative measure to reduce most of the negative impacts of conventional farming.

Organic farming is simply defined as form of agriculture excluding the use of synthetic fertilizer and pesticides. However broad meaning of organic agriculture is a production system that sustains the health of soils, ecosystems and the people. At present certain extent of fruit crops, plantation crops and spices are organically grown in Sri Lanka. Rice is staple food and occupies around 34% of total cultivated area in the country. During 2016/2017 *maha* season, the sown extent under paddy cultivation was 542,556 ha (Dept. of Census and Statistics, 2018). However, organic movement for paddy is still slow. Nearly 99% of the paddy fields in Sri Lanka are still cultivated under conventional farming where chemical inputs are heavily used (Dept. of Census and Statistics, 2018). It clearly indicates that true organic rice is restricted to very small area in the country. Several studies have been carried out to compare soil characteristics in organic and conventional farming. Some studies have shown that soil physical characters such as bulk density, soil structure and soil chemical characters such as cation exchange capacity (CEC), nutrient content, soil organic matter content and also soil biological properties are improved by organic farming than conventional farming (Reganold, 1998). According to some other studies, no significant difference of soil characteristics was reported between organic and conventional farming (Jenkins *et al*., 2011). However, sufficient studies have not been carried out to compare soil properties in organic and conventional rice farming in Sri Lankan contest. Hence this research was conducted to compare some soil characteristics in organic and conventional input systems in rice farming in Sri Lanka and to identify whether organic farming has positive impact on reducing heavy metal contamination and increasing soil fertility in rice fields.

## 2. Materials and Methods

### 2.1 Site Description, soil sampling and analysis

Three rice farming blocks were selected from *Batalagoda* (7.5995° N, 80.1019° E), *Rambawa* (8.4401° N, 80.5049° E) and *Eppawala* (8.1441° N, 80.4119° E) areas. One organic field and a conventional field were selected from each block. All organic fields had more than five years of farming history with totally organic inputs. Soil samples were collected just after harvesting. Each field was divided in to five plots and soil samples were collected randomly and compositely from each replicate at two depths of 0-15cm and 15-30cm using soil augers. Core samples were used to collect the soil samples for the determination of bulk density. Samples collected for microbial analysis were stored in polythene bags at the temperature of $4^0$C. Sample collected for chemical analysis were air dried at the room temperature and were crushed by using clean mortar and pestle to break the aggregated structure. Then, soil was passed through 2 mm sieve to remove clods and unwanted debris. Prepared soil samples were analyzed at Soil Science laboratory, Faculty of Agriculture, Rajarata University of Sri Lanka to compare soil characteristics of organic and conventional rice fields using standard analytical methods as tabulated below (Table 01).

**Table 01. Methods adopted to soil analysis**

| Parameters | Method |
|---|---|
| Soil pH | Potentiometric 1:2.5 soil water suspension (Jackson, 1973) |
| Soil EC | Soil water suspension 1:2.5(Bruah and Barthakur, 1997) |
| Soil CEC | Ammonium Acetate method (Chapman, 1965) |
| Available N | Kjeldahl method (Bremner 1960) |
| Available P | Olsen's method (Olsen and Sommers 1982) |
| Exchangeable K | Ammonium acetate (Jackson, 1973) |
| Soil organic matter | Walkely and Black (Walkely and Black, 1934) |
| Bulk density | Core (Keen and Raczkowaski, 1921) |
| Biomass carbon | Chloroform fumigation-incubation method (Jenkinson and Powlson, 1976) |

## 3. Results and Discussion

### 3.1 Soil pH

The interaction between location and soil pH was significant and two organic fields (*Bathalagoda and Rambewa*) recorded significantly ($p<0.05$) higher pH value compared to conventional fields in 0-15 cm soil depth (Table 01). However, soil pH (0-15 cm) between treatments in Eppawala location was not significant. No significant difference was observed of soil pH between organic and conventional fields at 15-30 cm depth in all three locations. Soil pH in *Bathalagoda* showed slightly acidic in nature while *Rambewa* soils had slightly to moderate alkaline soil reaction. Soil pH in *Eppawala* was close to 7 indicating near neutral condition. Previous studies conducted to differentiate soil characteristics between organic and conventional fields demonstrate different findings with respect to soil pH. Some studies showed higher soil pH in organic fields while some other argued that soil pH is low in organic fields compared to that of conventional fields. Maharjan, *et al*., (2017) reported that soil pH was higher in established organic plots than reference in *Kavare* district, Nepal. Similar results were observed in several other studies as well (Mader, *et al*., 2002; Marinari, *et al*., 2006; Van Diepeningen, *et al*., 2006; Das, *et al*., 2014). This could be attributed to the ability of OM to form aluminum-organo complexes with acid forming Al to decrease soil pH (Sollins *et al*., 1996). In contrast, Ponnamperuma (1972) described that adding organic matter courses reduction of soil pH due to formation of humic acids in decomposing organic matter in paddy soils.

### 3.2 Electrical conductivity (EC)

Soil EC is referred to as ability of soil water suspension to transmit electrical current. This is also a very useful indicator to measure the salinity of soil. Table 03 shows EC values of organic and conventional fields in 0-15 and 15-30cm soil depths. It indicates that soils in 0-15 cm depth in conventional fields had significantly higher ($p<0.05$) EC values than organic fields in all three locations. Chemical fertilizers which are commonly added to conventional fields are water soluble salts and they can increase soil EC. Clark *et al*., (1998) also confirmed that EC in conventional paddies was higher than in organic paddies and EC levels in the organic system were more stable. However, no difference of soil EC was observed between organic and conventional fields at 15-30 cm depth. Higher EC values were reported in topsoils in both input systems in all three locations depicting more salt accumulation in the soil surface. However, EC values do not indicate any potential threat for developing saline condition in any tested field.

### 3.3 Soil organic matter

Organic matter (OM) has a variety of positive impacts on soil quality and fertility. It increases availability of soil nutrients, encourages aggregate formation, enhances water storage and improves microbial activities. Organically cultivated lands showed higher soil OM percentage than conventional farmlands in many parts of the world (Reganold, 1998; Bulluck *et al*., 2002; Admeades, 2003). However, organic matter buildup in the soil is hindered by the high soil temperature especially in tropical environments. The mean OM percentages of tested organic and conventional fields are given in table 04. Organic fields in all three locations recorded significantly higher *($p<0.05$)* soil organic matter content compared to that of conventional fields. Highest OM percentages (4.6% at 0-15cm and 4.2% at 15-30 cm) were observed in *Eppawala* organic field. Informal discussions made with farmers in *Eppawala* location revealed that specially prepared organic manure including cow dung and partially burnt paddy husk were incorporated to their fields continuously for about five years. Previous studies also reported that, with the increase duration of organic management, there is an increasing trend in OM accumulation in the soil (Martini, *et al*., 2004; Tu, *et al*., 2006; Santos, *et al*., 2012;). When compared to 0-15 cm depth, soils from 15-30cm depth showed low OM percentage in all three locations. Use of rotavator plough in initial land preparation in paddy farming may have resulted mixing of OM more in shallow depth (0-15 cm) of the soil. Conventional farming fields also showed fairly good soil OM percentage. The possible reason could be use of combined harvester which directly disposes chopped straw into the field at harvesting.

### 3.4 Cation exchange capacity (CEC)

Soil CEC refers to the ability to retain cations in the soil. It is a good indicator to show soil fertility because soils with higher CEC are able to retain elements such as K, Ca and Mg which are essential to plant growth. Soil CEC was significantly higher ($p<0.05$) in organic fields compared to that of conventional fields in all three locations (Table 05). Reganold (1998) has described that higher CEC in organic fields can be attributed to the higher organic matter content because humus, the end product of the decomposed organic matter, has large quantity of negative charges to adsorb more cations. *Eppawala* location showed highest CEC level in both conventional and organic fields because of the higher organic matter content reported compared to other two locations. Parfitt, *et al*. (1995) also confirmed that there was a significant effect of interaction between organic matter on the CEC in A and B horizons in New Zealand soils. This result is also consistence with the findings of CUCE (2007) which has reported a positive correlation between OM content and CEC of tropical soil.

### 3.5 Soil available N

Soil available N is a fraction of the total N that can be readily absorbed by plant roots and microbes (Brady and Weil, 2014). Nitrogen from most of the commonly applied inorganic sources such as urea, ammonium nitrate and ammonium sulfate quickly become a part of the soil solution or the exchange complex when applied to moist soils. Difference in available N content between organic and conventional fields were significant ($p<0.05$) in all three locations (Table 06). Higher available N content was observed in conventional fields in both soil depths except 15–30 cm depth in Eppawala location. Accumulation of added fertilizer in the soil may have resulted higher available N content reported in conventional fields. Urea (N-46%) is the widely used N fertilizer in paddy farming in Sri Lanka. When urea is added into the moist soil, it gets hydrolysis and release $NH_4^+$ which is an important part of available N. However, conversion of $NH_4$ to $NO_3$ is slow in submerged soils due to lack of oxygen (Ponnamperuma, 1984). As a result, $NO_3$ leaching losses get reduces and more $NH_4$ remains exchangeable sites in topsoils. This may be the possible reason for higher available N content recorded in 0-15 cm depth in conventional fields. Gaskell and Smith, (2007) pointed out that, though organic fields reported higher soil OM content than conventional fields N releasing to soil solution is a remarkably slow process. This could be attributed to low available N content observed in organic fields. The similar result was obtained by Maharjan, *et al.* (2017) in the study on transition from conventional to organic input system in *Kavre* district, Nepal.

### 3.6 Exchangeable K

Potassium exists in several forms in the soil. Exchangeable K is the readily available K presence in exchangeable sites for plant uptake (Brady and Weil, 2014). No significant difference ($p>0.05$) of exchangeable K was observed between organic and conventional fields in all 03 locations (Table 07). The total mass of rice straw is incorporated to the soil unintentionally in both input systems at every harvesting because of the use of combined harvester. Rice straw contain about 1.0-3.7% K in available form (Ponnamperuma, 1984). In addition, different organic sources include considerable amount of K which can enrich exchangeable pool. It is fact that, the higher the soil CEC, the higher K retention in exchangeable sites (Brady and Weil, 2014). Since, organic soils reported higher CEC, higher K retention can be expected. This may be the possible reason to show comparable K levels in both organic and conventional fields, irrespective of adding K rich Murate of Potash (60% $K_2O$) for conventional fields.

**Table 02. Soil pH in three locations**

| **Farming system** | **Soil pH** | | | | | |
|---|---|---|---|---|---|---|
| | Batalagoda | | Eppawala | | Rambewa | |
| | 0-15cm | 15-30cm | 0-15cm | 15-30cm | 0-15cm | 15-30cm |
| organic | 6.3 $^a$ | 6.1 $^a$ | 7.2 $^a$ | 6.9 $^a$ | 8.4 $^a$ | 7.4 $^a$ |
| conventional | 5.6 $^b$ | 5.7 $^a$ | 6.6 $^a$ | 6.7 $^a$ | 7.2 $^b$ | 7.1 $^a$ |

(Figures in the same column followed by the same letters are not significantly different at α=0.05, LSD analysis)

**Table 03. Soil EC in three locations**

| Farming system | EC $dSm^{-1}$ | | | | | |
|---|---|---|---|---|---|---|
| | Batalagoda | | Eppawala | | Rambawa | |
| | 0-15cm | 15-30cm | 0-15cm | 15-30cm | 0-15cm | 15-30cm |
| organic | $0.24^{b}$ | $0.18^{a}$ | $0.27^{b}$ | $0.13^{a}$ | $0.16^{b}$ | $0.17^{a}$ |
| conventional | $0.62^{a}$ | $0.23^{a}$ | $0.48^{a}$ | $0.17^{a}$ | $0.42^{a}$ | $0.23^{a}$ |

(Figures in the same column followed by the same letters are not significantly different at α=0.05, LSD analysis)

**Table 04. Soil organic matter content in three locations**

| Farming system | Organic matter content (%) | | | | | |
|---|---|---|---|---|---|---|
| | Batalagoda | | Eppawala | | Rambewa | |
| | 0-15cm | 15-30cm | 0-15cm | 15-30cm | 0-15cm | 15-30cm |
| organic | $3.7^{a}$ | $2.7^{a}$ | $4.6^{a}$ | $4.2^{a}$ | $2.4^{a}$ | $1.9^{a}$ |
| conventional | $2.1^{b}$ | $1.8^{b}$ | $3.2^{b}$ | $2.3^{b}$ | $1.4^{b}$ | $1.1^{b}$ |

(Figures in the same column followed by the same letters are not significantly different at α=0.05, LSD analysis)

**Table 05. Soil CEC in three locations**

| Farming system | CEC ($cmolkg^{-1}$) | | |
|---|---|---|---|
| | Batalagoda | Eppawala | Rambawa |
| | 0-15cm | 0-15cm | 0-15cm |
| organic | $15.2^{a}$ | $16.3^{a}$ | $14.4^{a}$ |
| conventional | $8.3^{b}$ | $10.6^{b}$ | $9.8^{b}$ |

(Figures in the same column followed by the same letters are not significantly different at α=0.05, LSD analyzis)

### 3.7 Soil available P

The interaction between location and available P was significant. Two locations (*Bathalagoda* and *Rambewa*) depicted significantly higher (*$p<0.05$*) P level in 0-15 cm depth while no significant difference was observed in *Eppawala* (Table 08). Triple super phosphate is the common P fertilizer source in paddy farming in Sri Lanka and excessive application is witnessed in conventional farming. Therefore, increased soil P level reported in conventional paddy farming is somewhat common in many parts of the country. Similar results were depicted in a study conducted in Nepal, indicating higher P level in the fields under transitional stage compared to available P in totally organic fields (Maharjan, *et al.*, 2017).

Even though, organic fields reported low available P levels, these values are closer to critical P level (10 ppm) for paddy farming in Sri Lanka (Sirisena, *et al*., 2010). It revealed that organic sources also have potential to provide P to a considerable extent to support plant growth. On the other hand, conventional fields showed potential risk to buildup available P pool and create nutrient imbalances in the soil.

### 3.8 Soil Cd and As

Cadmium and arsenic are well recognized as toxic elements with high toxicity and carcinogenic properties. Both elements were identified as a possible etiological factor for the newly emerging epidemic of chronic kidney disease in dry zone, Sri Lanka (Jayasumana, *et al*., 2015 b). No significant difference ($p>0.05$) was reported in Cd and As between organic and conventional fields in all three locations. The reported As and Cd levels were well below 0.5 mg/kg in both organic and conventional fields in all three locations indicating minimum environmental risk. According to the Chandrajith, *et al*. (2004) submerged and reducing conditions in rice soils are favorable for the removal of As from the soil profile. Bandara, *et al*. (2010) has described that it is possible to remove Cd from submerged soils by prolonged leaching.

### 3.9 Bulk density

Soil bulk density provides many information such as soil compaction, aeration and solute movement in the soil (Brady and Weil, 2014). It is fact that higher the soil OM decreases the bulk density in mineral soils (Hossain, *et al*., 2015). However, result revealed that no significant difference ($p>0.05$) in bulk density between organic and conventional fields in all three locations (Table 09). According to the Reganold (1998) bulk density does not necessarily change as results of organic practices. It depends external factors like soil compaction due to use of heavy machines in land preparation.

### 3.10 Soil microbial biomass Carbon

Soil microbial biomass carbon is the weight of carbon contained within the microbes, living on soil organic matter. It mostly consists of bacteria and fungi, which decompose crop residues and organic matter in the soil. Significantly higher ($p<0.05$) biomass carbon content in organic fields was depicted in two locations (*Bathalagoda* and *Rambewa*) whereas *Eppawala* showed no significant difference ($p>0.05$) in biomass carbon content between organic and conventional fields. The results are in consistency with the findings of Bulluck *et al*. (2002), which observed higher numbers of enteric bacteria in soils with organic amendments than in soils with synthetic fertilizers.

**Table 06. Soil available N in three locations**

| Input system | Soil available N (mgkg$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | Batalagoda | | Eppawala | | Rambawa | |
| | 0-15cm | 15-30cm | 0-15cm | 15-30cm | 0-15cm | 15-30cm |
| organic | 12.8 $^{b}$ | 8.3 $^{b}$ | 14.8 $^{b}$ | 6.9 $^{a}$ | 13.2 $^{b}$ | 7.6 $^{b}$ |
| conventional | 38.1 $^{a}$ | 12.7 $^{a}$ | 27.4 $^{a}$ | 7.8 $^{a}$ | 36.4 $^{a}$ | 13.8$^{a}$ |

(Figures in the same column followed by the same letters are not significantly different at α=0.05, LSD analysis)

**Table 07. Soil exchangeable K in three locations**

| Input system | Exchangeable K (mgkg$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | Batalagoda | | Eppawala | | Rambawa | |
| | 0-15cm | 15-30cm | 0-15cm | 15-30cm | 0-15cm | 15-30cm |
| organic | 118.7 $^{a}$ | 89.1 $^{a}$ | 156.0 $^{a}$ | 94.7 $^{a}$ | 143.8 $^{a}$ | 87.8 $^{a}$ |
| conventional | 113.7 $^{a}$ | 78.47 $^{a}$ | 161.4 $^{a}$ | 82.6 $^{a}$ | 138.4 $^{a}$ | 76.7 $^{a}$ |

(Figures in the same column followed by the same letters are not significantly different at α=0.05, LSD analysis)

**Table 08. Soil available P in three locations**

| Input system | Available P (mgkg$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | *Batalagoda* | | *Eppawala* | | *Rambawa* | |
| | 0-15cm | 15-30cm | 0-15cm | 15-30cm | 0-15cm | 15-30cm |
| organic | 6.0 $^{b}$ | 3.5 $^{a}$ | 18.1 $^{a}$ | 14.2 $^{a}$ | 7.3 $^{b}$ | 5.2 $^{a}$ |
| conventional | 18.8 $^{a}$ | 5.4 $^{a}$ | 22.5 $^{a}$ | 12.4 $^{a}$ | 20.1 $^{a}$ | 6.2 $^{a}$ |

(Figures in the same column followed by the same letters are not significantly different at α=0.05, LSD analysis)

**Table 09. Bulk density in three locations**

| Input system | Bulk Density (Mgm$^{-3}$) | | |
|---|---|---|---|
| | *Batalagoda* | *Eppawala* | *Rambawa* |
| | 0-15cm | 0-15cm | 0-15cm |
| organic | 1.48 $^{a}$ | 0.96 $^{a}$ | 1.87 $^{a}$ |
| conventional | 1.43 $^{a}$ | 0.94 $^{a}$ | 1.72 $^{a}$ |

(Figures in the same column followed by the same letters are not significantly different at α=0.05, LSD analysis)

## 4. Conclusions

Findings of our study revealed that organic farming increases soil organic matter content and cation exchange capacity in organically managed paddy fields compared to these soil parameters of conventional paddy fields. Further, it demonstrates organic farming can results higher soil microbial biomass content indicating improved level of soil health. Organic fields are comparable with conventional fields in terms exchangeable K content in the soil. However, there is a challenge in increasing available N and P in organic fields up to required level for optimum production of rice.

**References**

[1]. Admeades, C.D. (2003). The long term effects of manures and fertilizers on soil productivity and quality. *Nutrient Cycling in Agro systems*, 66 (2):165-180.

[2]. Bandara, J.M.R.S., Wijewardana, H.V.P., Liyanage, J., Upali, M.A. and Bandara, J.M.U.A. (2010). Chronic renal failure in Sri Lanka caused by elevated dietary cadmium: Trojan horse of the green revolution. *Toxicology Letters*, 198(1): 33-39.

[3]. Brady N C and Weil R R. (2014). The nature and properties of soils, *Dorling Kindersley*, India.

[4]. Bremner J.M (1960). Determination of nitrogen in soil by the Kjeldahl method. *The Journal of Agricultural Science*. 55(1) 11:33.

[5]. Bullock, R.L., Brosius, M., Evanylo, K.G., and Ristanio, B.J. (2002). Organic and synthetic Fertilizer amendments influenced soil microbial, Physical and chemical properties on organic conventional farms. *Applied soil ecology*, 19: 147-160.

[6]. Bruah, T.C. and Barthakur, H.P. (1997). A Text book of Soil Analysis. Vikas Publishing house private limited,New Delhi.

[7]. Chapman, H.D. (1965). Cation Exchange Capacity. In: Black, C.A., Ed., Methods of Soil Analysis, American Society of Agronomy, Madison, 891-901.

[8]. Chandrajith, R., Dissanayaka, B.C., Tobschall, J.H. (2004). The abundance of rare trace elements in paddy (rice) soils of Sri Lanka. *Chemosphere,* 58(10): 1415-1420.

[9]. Chandarjith, R., Senavirathna, S., Wikramaarachchi, K., Attanayaka, T., Aturalya, C.N.T. and Dissanayaka. (2010). Natural radionuclides and trace elements in rice field soil in relation to fertilizer application: Study of a chronic kidney disease area in Sri Lanka. *Environmental earth science*, 60(1): 193-201.

[10]. Clark, M.S., William, R.H., Carol, S., and Scow, K.M., (1998). Changes in soil chemical properties resulting from organic and low-input farming practices. *Agronomy Journal*, 90: 663-671.

[11]. CUCE, Cornell University Cooperative Extension (2007). Cation exchange capacity. Agronomy fact sheet series -22, Department of crop and soil sciences, College of agriculture and life sciences, Cornell University.

[12]. Das, A., Patel, D. P., Kumar, M., Ramkrushna, G. I., Ngachan, S. V., Layek, J. and Lyngdoh, M. (2014). Influence of cropping systems and organic amendments on productivity and soil health at mid altitude of North East India, *Indian Journal of Agriculture Sciences,*12: 1525–1530.

[13]. Department of Census and Statistics, (2018). Paddy statistics. Retrieved on March 10,2018 from http:// statistics.gov.lk/agriculture/Paddy%20Statistics/PaddyStats.htm

[14]. Gaskell, M. and Smith, R. (2007). Nitrogen sources for organic vegetable crops. *Hort.Technol*. 17: 431-441.

[15]. Hossain, M.F., Chen, W. and Zhang, Y. (2015). Bulk density of mineral and organic soils in the Canada's arctic and sub-arctic. *Information processing in Agriculture*, 2, 3:4 183-190.

[16]. Jackson, M.L., (1973). Soil chemical analysis (Indian Edition). Prentice Hall of India Pvt. Ltd. New Delhi, India.

[17]. Jayasumana, P., Paranagama, P., Fonseka, S., Amarasinghe, M. Gunathilaka, S. and Siribaddana, S. (2015 a). Presence of arsenic in Sri Lankan soils. *International Journalof Food Contamination*. 2-5.

[18]. Jayasumana C, Gunatilake S, Siribaddana S. (2015 b). Simultaneous exposure to multiple heavy metals and glyphosate may contribute to Sri Lankan agricultural nephropathy. *BMC Nephrol* 2015; 16: 103.

[19]. Jenkins H.J.L., Sakrabani, R., Pearce, B., Whitmore, P.A. and Godwin, J.R. (2011). A comparison of soil and water properties in organic and conventional farming systems in England. *Soil Use and Management*, 27: 133-142.

[20]. Jenkinson, D.S. and Powlson, D.S. (1976). The effects of biocidal treatments on metabolism in soil. V. A method for measuring soil biomass. *Soil Biol. Biochem*. 8, 209-213.

[21]. Keen, B.A. and Raczkowski, H. (1921). The relation between clay content and certain physical properties of soil. The Journal of Agricultural Sciences 11(4): 441-449.

[22]. Mader, P., Fliebbach, A., David Dubois, D. Gunst, L. Fried, P. and Niggli, U. Soil (2002). Fertility and Biodiversity in Organic Farming, Science 296, 1694 – 1697.

[23]. Maharjan, B., Chaulagain, A., Sapkota, P., Gauchan, D.P., Lamichanne. J. (2017). Soil propertiesduring transition from conventional to organic farming system in Kavre district, Nepal. *Journal of Science, Engineering and Technology, Kathmandu University*,13:1, 76-84.

[24]. Marinari, S., Mancinelli, R., Campiglia, E & Grego S. (2006). Chemical and biological indicators of soil quality in organic and conventional farming systems in Central Italy, *Ecological Indicators*, 6:4, 701–711.

[25]. Martini, E. A., Buyer, J S., Bryant, D C., Hartz, T. K and Denison R F. (2004). Yield increases during the organic transition: improving soil quality or increasing experience? *Field Crops Research*, 86, 255–266.

[26]. Olsen, S.R. and Sommers ,E.C.(1982). Phosphorus. Methods of Soil Analysis Part 2. *Am. Soc.of Agron*. Madison, Wisconsin, U.S.A.pp 403-430.

[27]. Parfitt, R.L. Giltrap, D.J. and Whitton, J.S. (1995) Contribution of organic matter and clay minerals to the cation exchange capacity of soils, *Communications in Soil Science and Plant Analysis*, 26:9-10, 1343-1355.

[28]. Ponnamperuma, N.F. (1972). The chemistry of submerged soils. *Advances in Agronomy*, 24:29- 88pp.

[29]. Ponnamperuma, N.F. (1984). Chemical kinetics of wetland rice soils relative to soil fertility. *Proceeding of wetland soils characterization, classification and utilization workshop*, 25 march -5 April 1984, International Rice Research Institute, Philippines, 71-90pp.

[30]. Raganold, P.J. (1998). Comparison of soil properties as influenced by organic and conventional farming systems. *American Journal of Alternative Agriculture*, 3:144-155pp.

[31]. Sanjeevani, U.K.P.S., Indraratne, S.P., Weerasooriya, S.V.R. and Vitharana, W.U.A. (2012). Trace element baseline concentration in a selected soil map unit of Sri Lanka. *Proceedings of Peradeniya University Research Session*, 4th July, 2013.University of Peradeniya.17: pp 230.

[32]. Santos, V. B., Araújo, A. S. F., Leite. L. F. C., Nunes, L. A. P. L. and Melo, W. J. (2012). Soil microbial biomass and organic matter fractions during transition from conventional to organic farming systems, *Geoderma*, 170, 227-231.

[33]. Sirisena D.N, Rathnayake, W.M.U.K. and Bandara W.M.J. (2010). Availability and spatial variability of plant nutrients in paddy fields of wilgoda irrigation scheme in Kurunegala In: Evans, A.; Jinapala, K. (Eds.). *Proceedings of the National Conference on Water, Food Security and Climate Change in Sri Lanka*, BMICH, Colombo, Sri Lanka, 9-11 June 2009. Vol.2: Water quality, environment and climate change. Colombo, Sri Lanka: International Water Management Institute. 61-68 pp.

[34]. Sollins, P., Homann P.and Caldwell, B.A. (1996). Stabilization and destabilization of soil organic matter: mechanisms and controls. *Geoderma* 74 (1-2):65-105.

[35]. Tu, C., Louws, F. J., Creamer, N. G., Mueller, J.P, Browine, C., Fager, K., Bell, M. and Hu, S. (2006). Response of soil microbial biomass and N availability to transition strategies from conventional top organic farming systems, *Agriculture, ecosystems and environment*, 113 (2006), 206- 215.

[36]. Van Diepeningen, A. D., De Vos, O.J, Korthals, G. W. and Van Bruggen, A. H. C. (2006). Effects of organic versus conventional management on chemical and biological parameters in agricultural soils, *Applied Soil Ecology*, 31 (1-2), 120–135.

[37]. Walkley, A.J. and Black, I.A. (1934). Estimation of soil organic carbon by the chromic acid titration method. Soil Science 37(1): 29-38.