Environmental Soil Management

COMPARISON OF SOIL CHARACTERISTICS UNDER DIFFERENT INPUT RICE PPRODUCTION SYSTEMS: THE FIRST YEAR IN TRANSITION

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Rice (*Oryza sativa*) is one of the main agricultural crops in Sri Lanka. At present, rice farming in Sri Lanka is highly based on external inputs such as fertilizer and pesticides. However, many studies have revealed that long term use of chemical inputs creates adverse impacts on soil health. Hence, this study was conducted to compare soil characteristics of rice fields under organic, conventional and reduced input use production systems. The experiment was carried out in the research field, Faculty of Agriculture, Rajarata University of Sri Lanka during *Maha* cropping 2018/2019. Soil samples were collected from three production systems just after land preparation and maximum tillering stage and were analyzed for soil properties and characteristics. Data analysis was done by mixed procedure model using the Statistical Analysis System. Total nitrogen and available phosphorous of all three systems were significantly higher ($p<0.05$) at maximum tillering stage compared to initial levels. Significantly higher ($p<0.05$) total and ammonium nitrogen levels were reported in conventional system at maximum tillering stage compared to other systems. However, highest soil microbial activity at the maximum tillering stage was reported in organic system. Organic and reduced systems showed significantly higher ($p<0.05$) available P content at the maximum tillering when compared to initial levels. This may probably be due to microbial mineralization of soil P. Exchangeable Potassium, Cd, As and Pb were not significantly different ($p>0.05$) among three input systems. Results revealed that organic and reduced input systems showed better microbial activity than conventional system. However, long term investigations are needed to confirm other findings.

Keywords: High external input, Organic farming, Reduced input use system, Rice cultivation, Soil characteristics

NUTRIENT LEVELS AND TRACE ELEMENTS IN RICE PLANT UNDER DIFFERENT INPUT MANAGEMENT SYSTEMS: THE FIRST YEAR IN TRANSITION

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Rice plant nutrients uptake behaviour is very important in site-specific nutrient management (SSNM) to determine timing and doses of different nutrients. This study was conducted to investigate the impact of different inputs management systems (IMS) on bioaccumulation of nutrients and trace elements at different growth stages of rice plant. Leaf samples were collected at seedling, panicle initiation and 50% flowering stages from conventional (Department of Agriculture recommendation), reduced (50% Department of Agriculture recommendation and 50% organic manure) and organic manure applied plots. Leaf total Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and trace elements (Mn, Cu, Fe, Zn, As, Cd and Pb) were determined using standard analytical procedures. Data were statistically compared by mixed procedure and mean separation was done by Tukey's HSD test using SAS. Results revealed that, N, P, Ca, Mg, Cu, Mn, Pb and As of leaf tissues were significantly differed (p<0.05) across three IMSs. However, K, Fe, Zn, and Cd of leaf tissues were not significantly different (p>0.05) across IMSs. Leaf tissues contents of all analysed elements except Zn and P were significantly different (p<0.05) across the studied time periods. Plant uptake of all analysed elements except As, Cd and Pb in all three treatments were significantly higher at the 50% flowering stage in comparison to other growth stages. Differential plant uptakes of nutrients and trace elements were observed in three IMSs at each growth stage. Dry matter of each treatment has significantly increased at seedling, panicle initiation and 50% flowering stages across growing season (p<0.05) at three IMSs. Differences in uptake behaviours of rice plants in three IMSs emphasized the relevance of SSNM on the basis of IMSs.

Keywords: Input Management Systems, Paddy, Plant nutrients, Trace elements

NUTRIENT AND TRACE ELEMENT LEACHING IN PADDY SOILS UNDER DIFFERENT INPUT MANAGEMENT SYSTEMS: THE FIRST YEAR IN TRANSITION

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Detailed study of nutrient leaching provides a strong basis for the formulation of eco-friendly and economical site-specific fertilizer recommendations. Hence, this study was conducted to evaluate the leaching behaviour of nutrients and trace elements under conventional (Department of Agriculture recommendation), reduced (50% of DoA) and organic input management systems (IMSs) in rice grown in Low Humic Gley (LHG) soils. Leachate samples were collected from the field plot experiment conducted at the Faculty of Agriculture, Rajarata University of Sri Lanka. Porous PVC tubes were installed in the middle of each treatment plot just below the plough layer to collect leachate. The leachate samples were analysed for nutrients and trace elements using standard methods. Data were analysed following the mixed procedure. The results showed that NO_3^-- N and Arsenic (As) in leachate were significantly different (p<0.05) among different IMSs. The highest and lowest amount of NO_3^-- N leaching throughout the growing season were observed in conventional and organic rice plots respectively where the values were significantly different at before sowing stage while not significantly different (p>0.05) after sowing up to panicle initiation stage and 50% flowering stage. The higher As leaching was observed in conventional fields, whereas, it was comparatively lower in reduced and organic fields before sowing. Comparatively lower As leaching was observed after sowing stage, while as leaching was not detected at flowering stage in all IMSs. The pH, alkalinity, NH_4^+ - N, dissolved reactive P, exchangeable K^+, Na^+, Ca^{2+}, Mg^{2+}, Cd, Pb and Sodium Absorption Ratio were not significantly different among different IMSs, while significantly different over time. Moreover, Electrical Conductivity and Total Dissolved Solids were not significantly different among different IMSs as well as different time scales of the studied period. Different nutrients leaching behaviours in LHG under different IMSs emphasize the high relevance of eco-friendly and economical specific nutrient management on the basis of IMSs.

Keywords: Input management system, Leachate, Low Humic Gley, Nutrients,

IMPACT OF DRINKING WATER QUALITY AND LIFESTYLE FACTORS ON CHRONIC KIDNEY DISEASE OF UNKNOWN ETIOLOGY PREVELANCE IN *MALWATHUOYA* CASCADE

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Chronic Kidney Disease of unknown etiology (CKDu) is one of emerging health problems in Sri Lanka. Though the literature has reported many causal factors, the exact root causes responsible for the disease are still unknown. However, many studies have shown that poor drinking water quality and human lifestyles have significant impacts on the prevalence of CKDu. This study attempted to verify the impacts of water quality factors and lifestyle factors on CKDu prevalence in *Malwathuoya* cascade. Water samples were collected from CKDu prevalence and non-prevalence households in *Ihalagalkulama* and *Sivalakulama* Grama Niladhari Divisions of *Galenbindunuwewa* District Secretary Division. Samples were collected from wells used during past 25 years period by CKDu prevalence and non-prevalence households in study areas. Samples were tested for several water quality parameters. Information on lifestyle factors were also collected through a questionnaire survey. The study finds that the concentrations of As and hardness are significantly higher *($p<0.05$)* in CKDu prevalence households in comparison to non-prevalence households in *Sivalakulama*. Moreover, the average value of As in *Sivalakulama* lower than the SLS (614:2013) maximum permissible values, while the hardness and alkalinity of water are greater than the SLS maximum permissible values. The study could not identify significant differences of As, Pb, Mn and Fe in CKDu prevalence households compared to CKDu non-prevalence households in *Ihalagalkulama*. Moreover, alkalinity, As, Pb and Fe in both CKDu prevalence and non-prevalence households, Mn in CKDu prevalence households and NO_3^--N in CKDu non-prevalence households at *Ihalagalkulama* exceeded SLS set maximum permissible values. The questionnaire survey revealed that the most of CKDu patients are farmers (92%) and they expose to heavy sun during the field work. The results also revealed that higher the use of agrochemicals and exposure to agrochemicals, the greater the prevalence of CKDu in *Malwathuoya* cascade.

Keywords: CKDu, Life style factors, Water quality

TREATMENT OF BATHROOM WASTEWATER IN MICROBIALLY IMPROVED CONSTRUCTED WETLAND USING BULRUSH PLANT

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Constructed wetland (CW) systems have emerged as an alternative low cost and sustainable wastewater treatment systems. Combination of wetland plants and microbial inoculums have been identified as the most effective treatment in enhancing the pollution removal efficiency of CWs. Litreture revealed that CW system with bulrush (*Scirpus californicus)* plants was performed poorly in removal of certain pollutants. Hence, this study focused to enhance the pollution removal efficiency of CW with bulrush plants by introducing a fungal inoculum. The CW system was located in the Faculty of Agriculture, Rajarata University of Sri Lanka. The fungal inoculum was added to the soil surface of the CW with already established bulrush plants. The grey water discharged from a student hostel complex was directed in to the wetland at the average rate of 0.75 m^3 h^{-1}. The hydraulic retention time was 45 hrs. Water quality parameters of the influent and effluent were monitored in two week intervals for a period of four months by analysing biological oxygen demand (BOD_5), nitrate-nitrogen (NO_3^--N), ammonium - nitrogen (NH_4^+-N), phosphate - phosphorous (PO_4^{-3}-P), total dissolved solid (TDS), dissolved oxygen (DO), pH and electrical conductivity (EC). The results revealed that the system reduced the concentration of contaminants with the increasing removal efficiencies (REs) throughout the monitoring period. The average REs of BOD_5, NO_3^--N, NH_4^+- N, PO_4^{-3}-P were 59.6%,40.5%, 28.7%, 72.6% respectively. The average pH (6.84) of the effluents was ranged around the neutral, TDS (237.3 mg L^{-1}) and EC (313.2 S cm^{-1}) also ranged within the permissible level following the natural standards for waste water. Overall it can be concluded that the microbially improved CW performed effectively in removal of all measured parameters, comparatively highest in removal of PO_4^{-3}-P. However, repeated studies would be needed for a concrete conclusion.

Keywords: Constructed wetlands, Fungal inoculum, Greywater treatment, Removal efficiency

SOIL AND WATER QUALITY CHARACTERISTICS OF AGRO-WELLS IN NEWLY DEVELOPED FARMLANDS IN MAHAWELI SYSTEM L – *ATHAWATUNUWEWA* BLOCK

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Agro-wells are the most reliable water resource in newly developed farmlands in Mahaweli System L. However, water quality of agro-wells and its relationship with nutrient management in surrounding farmlands have not yet investigated. This study was conducted to investigate agro-well water quality, to explore its relationship with soil nutrient management and to explore short-scale soil spatial variability of surrounding areas of agro-wells. Water samples were collected from 10 agro-wells located in the study area at three time points. Soil samples from surrounding farmlands of each agro-well were also collected from 0-15 cm depth. In addition, intensive soil sampling was done surrounding a selected well to prepare soil short-scale spatial variability maps using Inverse Distance Weighting interpolation technique. Water samples were analysed for pH, EC, TDS, Mg, Ca, Na, K, NO_3-N, NH_4-N, Available phosphorus, Available Sulphur and Cd, As, Pb. Moreover, Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) were calculated of each water sample. Measured water quality parameters were compared with FAO guidelines. Soil samples were analysed for pH, EC, Available N, P, K, Mg, Ca, Na, S and total N, Cd, As, Pb. Correlation analysis was performed to investigate relationship between soil and water quality parameters of measured nutrients. All water quality parameters except NO_3-N, K and Cd were within acceptable range. K, Cd in all studied agro-wells and NO_3-N levels in 6 agro-wells have exceeded the maximum permissible level. Correlation analysis revealed a strong positive linear correlation between soil and water concentrations of NO_3-N ($r = 0.83$) Available Sulphur ($r = 0.81$) and Ca ($r = 0.82$). Natural short-scale spatial variability pattern of soil N, P, K in the studied area have been altered due to anthropogenic activities such as fertilizer applications.

Keywords: Agro-well, Soil spatial variability, Water quality

REPLACING TRIPLE SUPER PHOSPHATE FROM BIOFILM ENRICHED *EPPAWALA* ROCK PHOSPHATE IN RICE CULTIVATION

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Combined application of biofilmed biofertilizer recommended for rice (Biofilm-R) and *Eppawala* Rock Phosphate (ERP) has a greater potential to be used as an alternative to Triple Super Phosphate (TSP). Hence, this study was mainly focused to evaluate the TSP replacing potential of Biofilm-R–enriched ERP in rice cultivation, using a soil leaching tube experiment under laboratory condition. A modified chemical fertilizer (CF_M) mixture was developed by replacing TSP in the rice fertilizer recommendation (CF_E) of the Department of Agriculture (DoA) from Biofilm-R - enriched ERP. However, nitrogen (N) and potassium (K) levels were maintained according to the DoA recommendation. Six treatments were used with CF_E and CF_M at the different rates (65%, 85% and 100%) of Biofilm-R- enriched ERP. Soil alone was used as the control. The experiment was arranged in a completely randomized design with three replicates. Soil pH, available N and P, organic matter (OM) and microbial biomass C were measured before and after the experiment. In every two weeks, solubilized P was recovered by leaching for three months. Initial soil showed an optimum pH (7.27) and also had sufficient amounts of available N (77 $mgkg^{-1}$), available P (14.38 $mgkg^{-1}$) and exchangeable K (107 $mgkg^{-1}$) for rice plant growth. However, OM (1.14%) and microbial biomass C (2.68 mgg^{-1}) were very low. In leachates, 100% ERP coupled Biofilm-R recorded significantly ($p<0.05$) higher solubilized P compared to other treatments. Overall, biofilms applied treatments recorded higher microbial biomass at the end. Results conclude that 100% ERP coupled with Biofilm-R in the CF_M performed better than the DOA recommended TSP dosage. Therefore, Biofilm-R enriched 100% ERP can be proposed as an alternative to TSP in rice cultivation. However, further studies are needed to evaluate the effectiveness of this Biofilm-R enriched 100% ERP under field conditions.

Keywords: Biofilms, *Eppawala* rock phosphate, Triple super phosphate

MICROBIAL BIOFILMS FOR BIOSOLUBILIZATION OF *EPPAWALA* ROCK PHOSPHATE

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Biofilms are complex multi-cellular communities of microbes, some of them have potential to biosolubilize certain nutrients in the substrate. National Institute of Fundamental Studies (NIFS) has developed four biofilm formulations (BF1, BF2, BF3 and BF4) with the potential of solubilizing phosphorus (P) in *Eppawala* Rock Phosphate (ERP) and they have shown promising results in preliminary studies. Thus, this study was designed to evaluate the efficacy of these biofilm formulations in solubilizing ERP. A laboratory tray experiment was conducted under controlled conditions in a completely randomized design with three replicates. Five treatments were tested; the four biofilm formulations were sprayed separately (1.7 L of biofilms per 100 kg of ERP) into trays with a thin uniform layer of autoclaved ERP and also a control tray without a biofilm. Data were statistically analysed using analysis of variance followed by mean separation using Tukey's HSD test. Available P, water soluble P, microbial biomass C and P, pH and other microbial observations were taken in two weeks intervals for three months. Results revealed that BF3 was significantly higher ($p<0.05$) in releasing cumulative available P (279.9 $mgkg^{-1}$), water soluble P (160.7 $mgkg^{-1}$), biomass P (212.9 $mgkg^{-1}$) with the heaviest microbial biomass (2.3 mgg^{-1}) attached with ERP, compared to the other tested biofilms. All the biofilm treatments showed acidic pH throughout the experiment since they were producing organic acids when solubilizing P. The overall results conclude that the BF3 is the most efficient biofilm formulation in solubilizing ERP. Thus, further studies are recommended to evaluate the potential of using BF3 under field conditions in enhancing the solubilization of ERP.

Keywords: Biofilms, Biosolubilization of phosphorous, *Eppawala* rock phosphate

EFFECT OF DIRECT DISPOSAL OF REVERSE OSMOSIS CONCENTRATE ON SOIL CHEMICAL CHARACTERISTICS IN DISPOSAL SITES

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Reverse Osmosis (RO) is one of the most effective methods to provide safe drinking water for chronic kidney disease affected areas in the North Central Province, Sri Lanka. The rejected water or the concentrate of many RO plants is about 75% of the feed water volume. The concentrate disposed from RO plants includes all the removed through RO membrane. Direct disposal of RO concentrate into the soil may create long term environmental issues. Hence, this study was conducted to analyse the soil chemical characteristics of RO concentrate disposal sites. Ten community-based RO plants were selected to collect soil samples. Reference soil samples were also collected from non-affected locations of the same sites to compare soil characteristics. Both soil samples were analysed using standard methods for chemical characteristics. Soil analysis revealed that disposal of RO concentrate has significantly enhanced *($p<0.05$)* pH, EC, available N, P, K, Ca, Mg, Na, and Cu of the soil compared to the reference soil samples in all 10 locations. Studied four locations had remarkably higher percentages of EC, available Na, Mg and Ca (i.e: 87%, 96%, 90%, 80% respectively) than the reference soil. However, Cd, As and Pb accumulation in concentrate disposal sites was not significantly different (*$p>0.05$*) compared to reference samples. Water quality analysis showed significantly higher *($p<0.05$)* levels of EC, TDS, NO_3^-, PO_4^{3-}, Pb, Na, K, Ca, Cl, F and Mg contents in the concentrate compared to feed water in all the tested RO plants. However, no significant difference was reported in Cd, As, and Zn between feed water and the concentrate. Hence, there is a potential to build up salinity and sodicity in RO concentrate disposal sites and deteriorate soil health in the long term. However, this study should be continued to confirm long term effects.

Keywords: Concentrate, Direct disposal, Reverse osmosis, Soil characteristics, Water quality